Level 1 Product Generation System (LPGS)

System Requirements Review/ System Design Review

December 10, 1996

LPGS System Reqs/System Design Review

Agenda

• Introduction	J. Henegar
• System Concept	J. Henegar/K. Jeletic
• Requirements	R. Hamilton
• Operations Concept	A. Bernard
• System Design	K. Jeletic
• Conclusion	J. Henegar

LPGS System Reqs/System Design Review

- **Introduction**
  - Purpose of Presentation
  - Project Overview
  - Project Documentation
  - RID Information

LPGS System Reqs/System Design Review

Presentation Purpose

- Purpose of review
  - Present a synopsis of the LPGS System Requirements Analysis, Operations Concept Definition, and System Design Efforts
  - Obtain approval of the LPGS Level 3 Requirements, Operations Concept, and System Design from the Technical Review Panel
    - Insure that the LPGS Requirements and Ops Con are accurate and complete
    - Insure that the System Design will meet the requirements allocated to the LPGS, within the cost baseline at an acceptable risk

LPGS System Reqs/System Design Review

Presentation Purpose

- Scope
  - Operation Concept Definition Encompasses:
    - Defining the initial operational concept
  - System Requirements Analysis Encompasses:
    - Decomposing and deriving functional requirements
    - Decomposing and deriving performance requirements
    - Deriving operational requirements from the ops concept
    - Providing requirements traceability to higher level requirements
  - System Design Encompasses:
    - Allocating requirements to functions
    - Partitioning functions to subsystems
    - Defining internal and external interfaces
    - Developing system architecture
    - Analyzing system operations
    - Performing studies to guide design, mitigate risk

LPGS System Reqs/System Design Review

LPGS Technical Review Panel

- Ludie Kidd/L7 Implementation Manager — Co-Chair
- Daniel DeVito/ESDIS Systems Engineer — Co-Chair
- Jim Andary/L7 System Manager
- Jim Irons/Deputy Project Scientist
- Shaida Johnston/IAS System Engineer
- Robert Schweiss/LPS System Engineer
- Daniel Marinelli/ESDIS System Engineer
- Darla Werner/EDC L7 Ground System Manager
- Lyn Oleson/EDC DAAC Representative
- Jim Ellickson/NOAA

LPGS RIDS

- Please submit RIDS to Joy Henegar no later than December 23, 1996
  - Submission can be by using hardcopy RID provided or via email. Please make sure all information necessary on the hardcopy is provided on the email version.
    - Code 514, Bldg 23 Rm W215
    - joy.henegar@gsfc.nasa.gov
- Items to RID are:
  - Presentation Package
  - LPGS Operations Concept Document
  - LPGS Functional and Performance Requirements Specification
  - LPGS System Design Specification

On-line Documentation

- All LPGS baselined documentation, presentations or documentation available for review is available on the LPGS web server:

http://lpgs-server.gsfc.nasa.gov

Project Overview

- Funding for the LPGS was approved in April, 1996
- LPGS is an element of the ESDIS Project
- Operational LPGS will reside at the EDC DAAC in Sioux Falls, SD
- LPGS Goals
  - Maximize throughput and provide flexibility for expansion
  - Reuse level 1 algorithm implementations provided in the Image Assessment System
  - Provide maximum functionality within allocated budget

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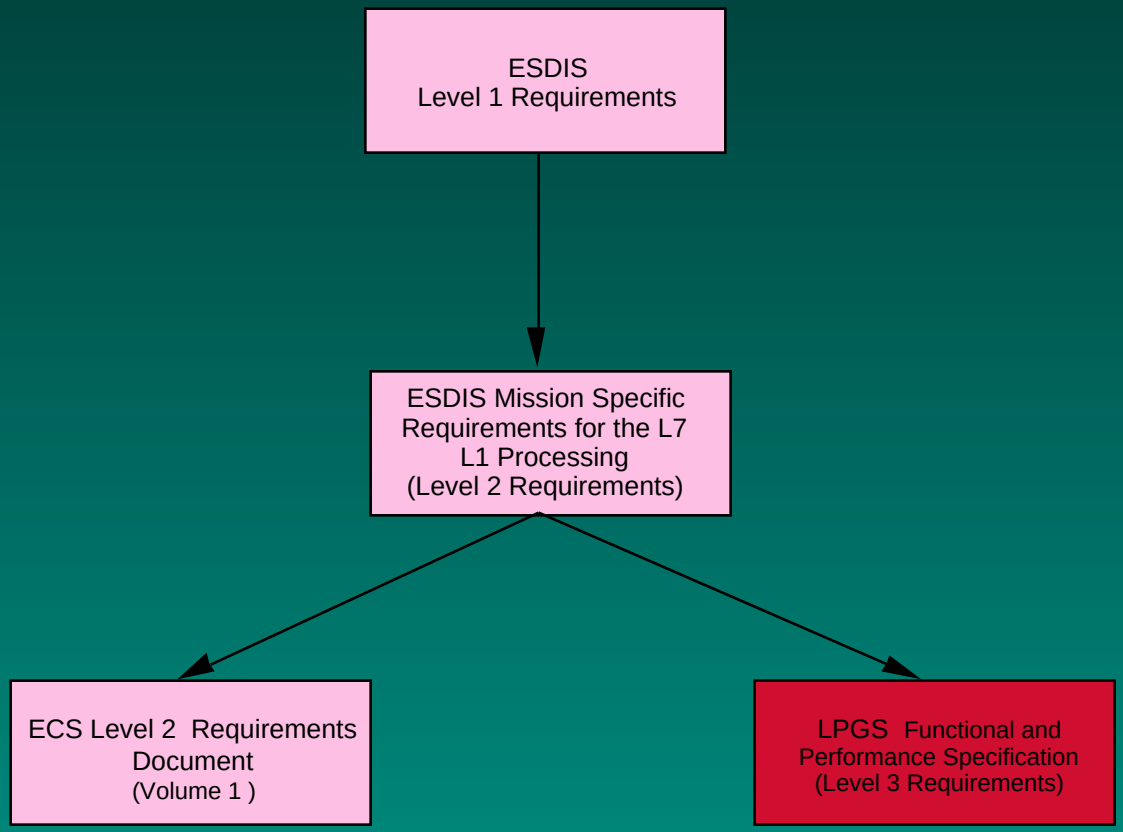
Requirements Traceability



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Documentation Issues

- ESDIS Mission Specific Requirements for Landsat 7 Level 1 Processing Requirements have not yet been baselined
  - CCR has been generated. Planning for baselining at the ESDIS January CCB
  - Draft Level 2's have been reviewed by LPGS, ESDIS, and EDC personnel
  - LPGS F&PRS traces to a 10/17 version of the Level 2 requiremetns
- Interface between LPGS and IAS has not been reflected in L7 requirements documentation but is reflected in LPGS requirements
  - CCRs will be generated against appropriate documentation to implement such an interface

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- System Design
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System Concept

- Ground System Overview
- Definitions
- LPGS Context Diagram
- Basic Functions
- System Trade

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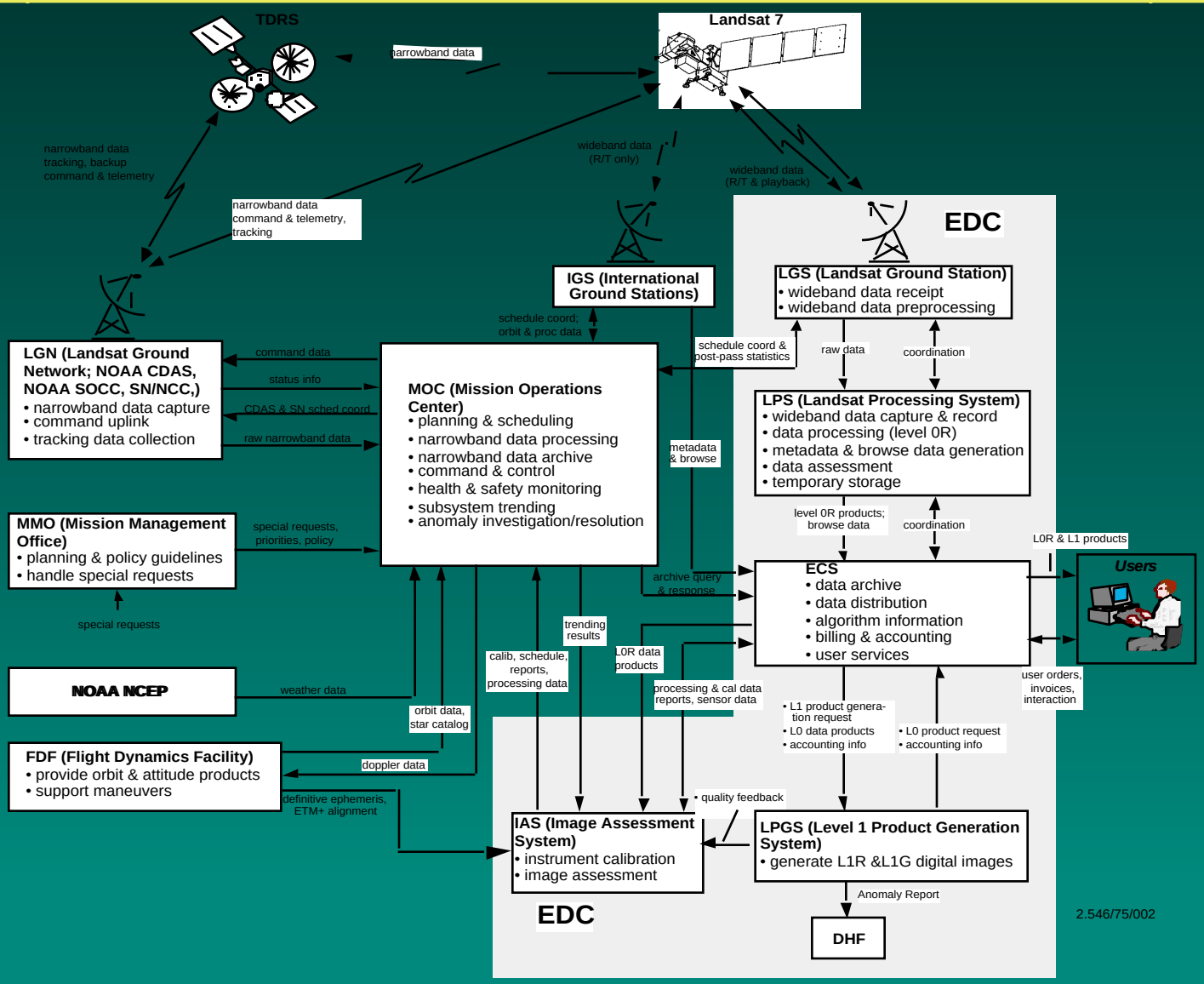
L7 Ground System Overview



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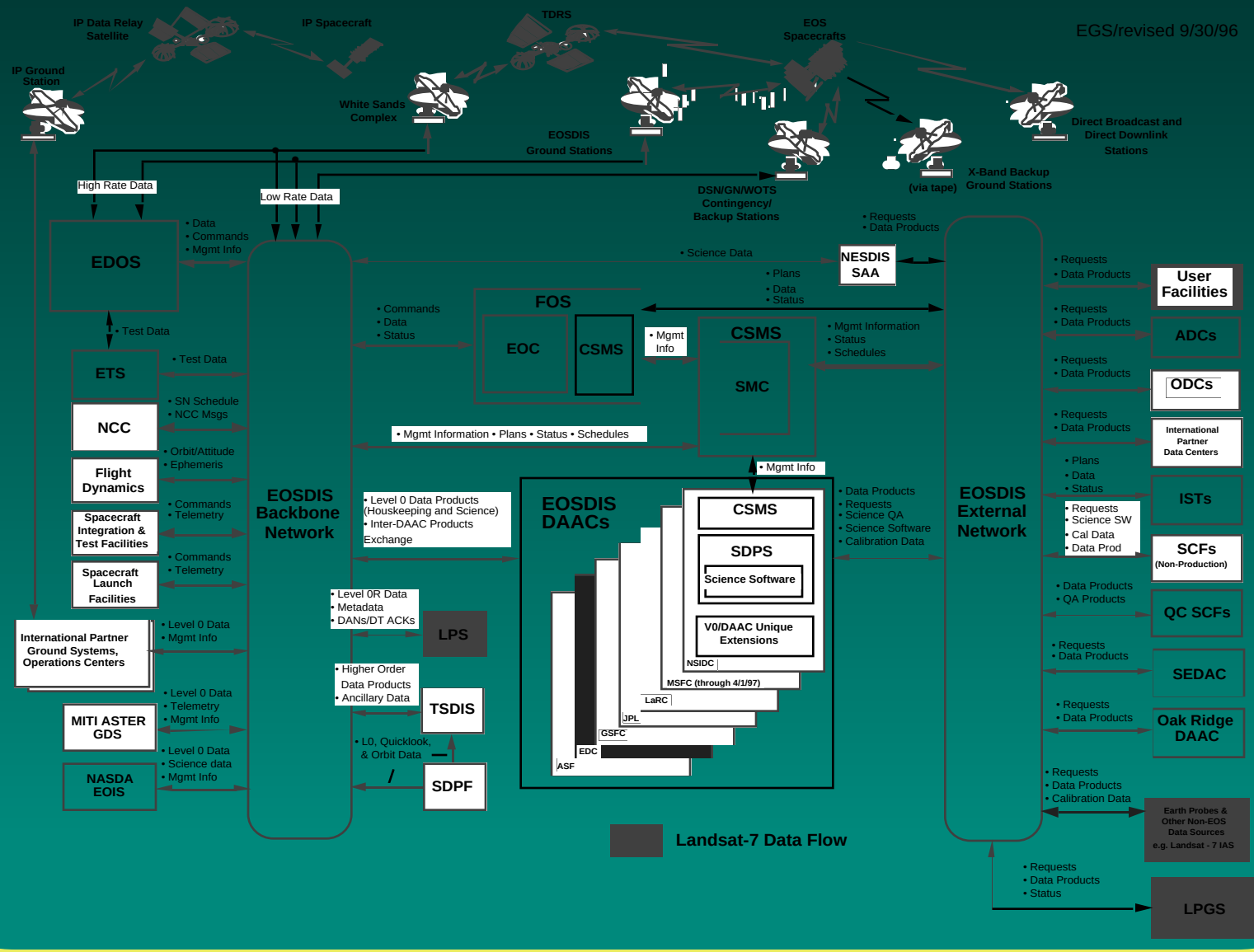
EOSDIS Ground System Overview



Definitions

- Level 1R (L1R) digital image–Radiometrically corrected but not geometrically resampled. Size can range up to 3 WRS scene equivalents. Floating scene based but is restricted to 1 interval.
- Level 1G (L1G) digital image–Radiometrically corrected and resampled for geometric correction and registration to geographic map projections. Size can range up to 3 WRS scene equivalents. Floating scene based but is restricted to 1 interval.
- Production Data Quality Assessment–Ancillary information collected and generated during L1 processing; provides information on the certainty with which corrections were made to images; nominally appended as a file to the L1 product
- Level 1 Products - Collection of data distributed from the ECS to the user

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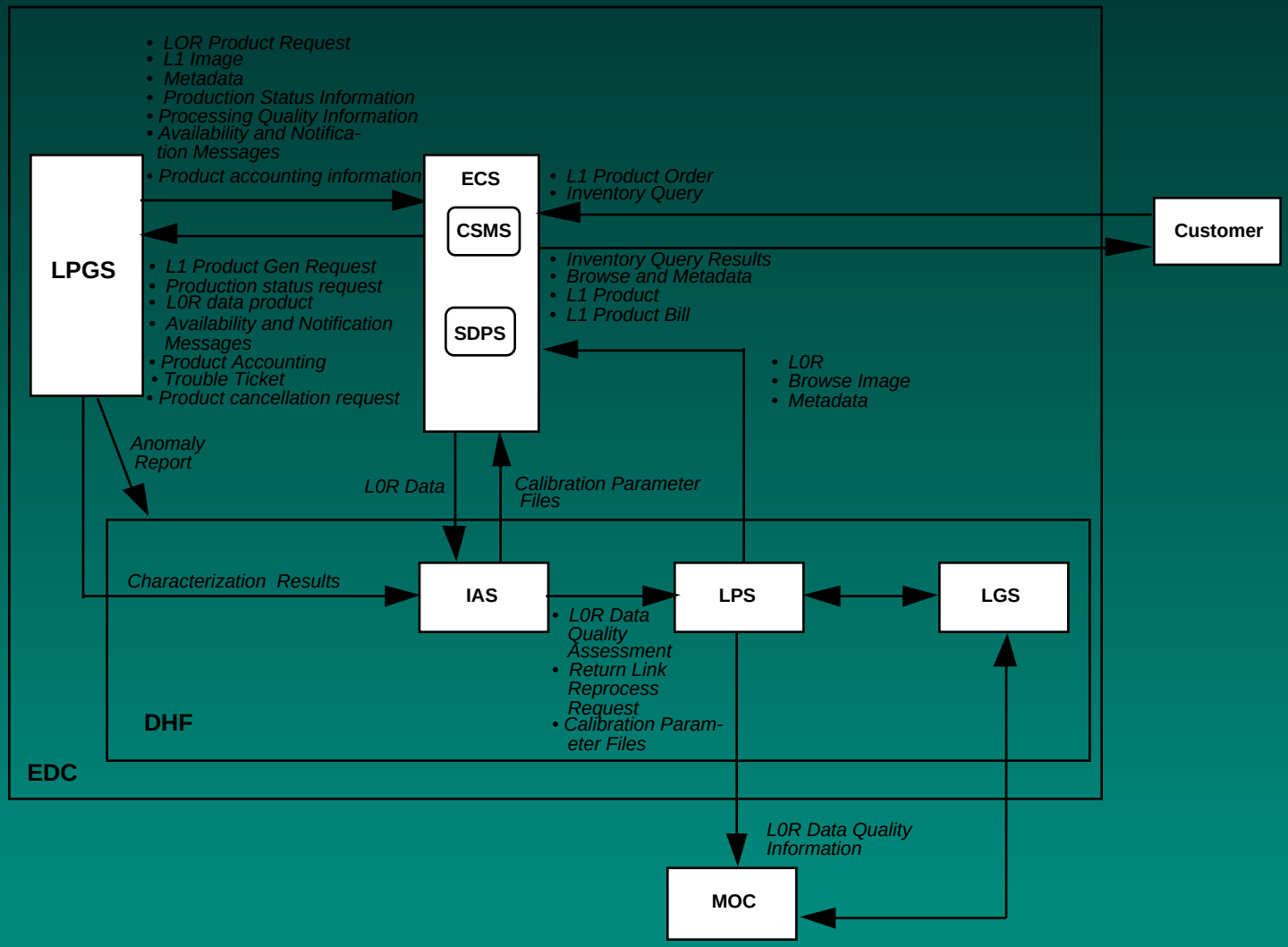
LPGS Context Diagram



LPGS External Interfaces

ELEMENT INTERFACE	INPUTS TO LPGS	OUTPUTS FROM LPGS
ECS	· L1 product generation request · Production status request · L0R data product · Accounting for L1 product distribution · Trouble ticket information · L1 product generation cancellation request · Availability and notification messages	· L0R product request · L1 image · Metada · Production status information · Processing quality and assessment information · L1 product accounting information · Availability and notification messages
IAS		· Characterization results
DHF		· Anomaly report

LPGS Basic Functions

- Receive and Process L1 Product Requests from the ECS
- Plan L1 Data Production
  - Processing done on first come, first serve basis. An operator can override this priority scheme if necessary.
  - Process product request cancellations as appropriate
  - Report product request status to the ECS
- Request and Receive L0R products from the ECS
- Generate Radiometrically or Geometrically Systematically Corrected digital images
- Reprocess requests as necessary
- Collect Performance and Quality Information
  - Provides automated quality checking of the L1 image
  - Provides capability for operator to visually inspect image if necessary
  - Provides quality and accounting statistics to the IAS
- Provide L1 digital images, metadata, and production quality information to the ECS for distribution

Level 1 Product Contents

- Level 1 Product Contents
  - L1 Digital Image — LPGS
  - Production Quality Info — LPGS
  - Calibration Parameter File — ECS
  - Payload Correction Data (1R only) — ECS
  - Mirror Scan Correction Data (1R only) — ECS
  - Internal Calibration Data — ECS
  - Metadata — LPGS

System Trade Study

ARCHITECTURE TRADE

- Criteria include schedule, cost, risk
- Alternatives included:
  - LPGS incorporated into ECS as an integrated science software user (similar to MODIS/ASTER)
  - LPGS as a stand-alone system
  - Hybrid of integrated science software user/stand-alone
- LPGS will be a stand-alone system
  - Minimize impact to ECS

- Requirements allocated to other EGS components:
  - ECS to provide:
    - All interaction with customer (data search, product order, order status, order cancellation, product distribution, cost estimation, billing, accounting, collection, user feedback)
    - Packaging of final Level 1 product
      - LPGS supplies Level 1 digital image, metadata, production quality summary
      - ECS packages LPGS-supplied data with user-requested data (PCD, MSCD, internal calibrator data, calibration parameter file)
  - EOSDIS Backbone Network (EBnet) to provide network and communication services in support of Level 1 processing

System Trade Study

USE OF NLAPS

- **PROS**
  - **NLAPS is already developed and in use operationally at EDC in support of several missions**
  - **Operators are already familiar with system**
- **CONS**
  - **We would have to develop algorithms anyway**
  - **Provides no schedule relief - algorithm development time + time for vendor to integrate them into their COTS product**
  - **Potential impact to ECS interfaces**
  - **Divergence with IAS**
    - **Reduce the amount of reuse**
    - **Increase level of maintenance**
- **DECISION: Not to use NLAPS**

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AGENDA

- Traceability
- Functional Requirements
  - Level 1 Image Generation
  - Quality Assessment
  - Image Formatting
  - Data Transfer
  - Storage
- Operations Support
- Performance Requirements

Traceability

- LPGS functional and performance requirements trace to the:
  - ESDIS Landsat 7 Level 1 Processing Requirements Specification (10/7/96 - Review Draft)
- LPGS requirements only partially satisfies the ESDIS level 1 processing requirements for Landsat 7. Requirements associated with customer interface, billing, product packing and distribution were allocated to ECS and EBnet.

Functional Requirements

- Process Level 0R products to produce radiometrically corrected level 1R images. [FPRS 3.3.2]
- Process Level 1R images to produce systematically corrected level 1G images. [FPRS 3.3.3]
- Generate Level 1 digital images corresponding to either standard world-wide reference system (WRS) scenes or to a partial ETM+ sub-interval up to an area equivalent to three WRS scenes. [FPRS 3.1.21]
- [Note: The Level 1R or 1G digital images generated by the LPGS will be bound by the contents of the corresponding standard Level 0R scene product.]

Functional Requirements (cont.)

- Receive L0R data inputs from the ECS. To include the following items: [FPRS 3.3.1.1]
-
  - Level 1 product request that includes:
    - Level 1R or Level 1G product selection
    - Scene or subinterval identification
    - Spectral band(s)
    - Orientation (Nominal Path or North-up)
    - Coordinate reference system for map projection
    - Variable grid cell size
    - Resampling Filter
    - Output product format selection
  - Level 0R files(includes PCD, MSCD, and Calibration files[IC & Parm])
  - Cancellation requests
  - Trouble Ticket Information(Problem Report)

LPGS System Reqs/System Design Review

Functional Requirements (Cont.)

- Generate level 1 digital images on demand based on submission of user orders. (First in -First out[FIFO]) [FPRS 3.1.1]
- Provide option to move a level 1 product processing work order within the FIFO queues according to operator direction. [FPRS 3.1.2]
- Support Landsat 7 operations for a minimum mission life of 5 years. [FPRS 3.1.12]
- Provide scaleable design to allow for future growth in processing capability. [FPRS 3.1.20]
- Make all software and databases used in operations accessible to ECS for archiving. [FPRS 3.1.19]

Functional Requirements (Cont.)

- Extract and process spacecraft jitter, attitude and ephemeris data from the L0R Payload Correction Data(PCD) files. [FPRS 3.3.2.1]
- Extract and process radiometric calibration coefficients from the L0R Calibration Data files. [FPRS 3.3.2.2]
- Extract and process scan quality data from the mirror scan correction data(MSCD) files. [FPRS 3.3.2.4]
-
- Extract and process instrument gains and biases from Internal Calibrator or Calibration parameter file. [FPRS 3.3.2.3]

Functional Requirements (Cont.)

- Detect, characterize and apply compensation for the following image artifacts [FPRS 3.3.2.5, 3.3.2.6, and 3.3.2.7]:
  - Striping
  - Banding
  - Coherent Noise
  - Memory Effect
  - Scan Correlated Shift
  - Inoperable Detectors(Compensation Only)
  - Saturated Detectors
  - Dropped Scan Lines

Functional Requirements (Cont.)

- Apply compensation for gain changes within a requested level 1 scene or subinterval as identified in the Level 0 metadata. [FPRS 3.3.2.8]
- Process both ascending(Night) and descending(Day) pass L0R data. [FPRS 3.3.2.9]
- Produce L1 digital images for any combination of the eight spectral channels. [FPRS 3.3.2.10]

Functional Requirements (Cont.)

- Assemble and append to the L1 digital images all of the applicable metadata and quality and accounting data gathered in the construction of the L1 digital image. The complete L1 digital image package contains the following data elements as a minimum: [FPRS 3.3.2.11 & 3.3.3.8]
  - Level 1 Digital Image (all requested bands)
  - Level 1 Metadata files
  - Quality and Accounting file

[NOTE: PCD, MSCD, and Calibration data will be appended by the ECS prior to customer distribution]

Functional Requirements (Cont.)

- Resample L1G digital images and apply the either of following the 7 map projections [FPRS 3.3.3.1]:
  - Space Oblique Mercator
  - Universal Transverse Mercator(UTM)
  - Lambert Conformal Conic
  - Transverse Mercator
  - Oblique Mercator
  - Polyconic
  - Polar Stereographic

Functional Requirements (Cont.)

- Support the following 3 compensation resampling methods [FPRS 3.3.3.2]:
  - Nearest Neighbor
  - Cubic Convolution
  - Modulation Transfer Function(MTF)

Functional Requirements (Cont.)

- Generate L1G digital images with the following grid cell characteristics [FPRS 3.3.3.3]:
  - The grid cell size is variable from 15 Meters to 60 Meters in 1 millimeter increments.
  - The grid cell size is independently variable between spectral bands.

Functional Requirements (Cont.)

- Produce L1G digital images that are spatially continuous between contiguous partial sub-intervals or WRS scenes. [FPRS 3.3.3.4]

- Generate L1 digital images oriented to either: [FPRS 3.3.3.5]:
  - Nominal Path (Spacecraft track)
  - North Up

Functional Requirements (Cont.)

- Generate ancillary metadata that describes the Level 1 image contents, processing parameters, and quality indicators. [FPRS 3.3.4.1 & 3.3.4.2]
-
- Support automatic assessment of Level 1 digital image quality based on operator selectable thresholds. [FPRS 3.3.5.1]
- Optionally display any band of the L1 digital image for visual quality assessment [FPRS 3.3.5.2 & 3.3.5.3]
- Optionally print a color hard copy of any band of the L1R digital image for visual quality assessment. [FPRS 3.3.5.4 & 3.3.5.5]

Functional Requirements (Cont.)

- Output Level 1 digital images in the following formats [FPRS 3.3.6.1]:
  - HDF-EOS (Hierarchical Data Format)
  - Eosat FAST-Format (L1G Only)
  - GeoTIFF (L1G Only)

Functional Requirements (Cont.)

- Notify the ECS on the availability of LPGS files ready for transfer. [FPRS 3.3.6.2]
- Display LPGS level 1 file transfer summary upon operator request. [FPRS 3.3.6.3]
- Detect files which have been successfully transferred. [FPRS 3.3.6.4]
- Mark successfully transferred files as candidates for deletion from LPGS temporary storage. [FPRS 3.3.6.5]

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Functional Requirements (Cont.)

- Provide temporary storage for L1R and L1G products for 72 hours. [FPRS 3.3.7.1]
- Provide capability to relocate file located in temporary storage. [FPRS 3.3.7.2]
- Store Level 1 processing information on-line for 90 days [FPRS 3.3.7.3]
- Provide capability to transfer Level 1 processing information to off-line storage after 90 days. [FPRS 3.3.7.4]
- Provide capability to recovery, display, and print Level 1 processing information for the life of the mission. [FPRS 3.3.7.5]

Operations Support Requirements

- Provide the capability to monitor and control LPGS operations. [FPRS 3.1.15 & 3.1.16]
- Provide system start up and shutdown capability [FPRS 3.1.3 & 3.1.4]
- Support attended operations 24 hours per day, 7 days per week, on a continuous basis. [FPRS 3.1.10]
- Support unattended, automatic processing 16 hours per day, 7 days per week, on a continuous basis. [FPRS 3.1.11]
- Provide capability to move Level 1 work orders within FIFO processing queues. [FPRS 3.1.2]

Operations Support Requirements (Cont.)

- Provide the capability to reconfigure LPGS system resources. [FPRS 3.1.17]
- Provide the capability to support software upgrades while supporting normal operations. [FPRS 3.1.18]

Operations Support Requirements (Cont.)

- Allow the operator to select thresholds for statistics and errors reported by the LPGS. [FPRS 3.3.8.1]
- Automatically generate messages and alarms to alert the operator of LPGS results and errors exceeding operator selected thresholds. [FPRS 3.3.8.2]
- Generate intermediate processing summaries on a periodic basis according to operator specification. [FPRS 3.3.8.3]

Operations Support Requirements (Cont.)

- Provide an option to display Level 1 digital image quality status and statistics at operator request. [FPRS 3.3.8.4]
- Provide an option to print Level 1 digital image quality status and statistics at operator request. [FPRS 3.3.8.5]
- Provide the capability to manually override the LPGS automated processing functions . [FPRS 3.3.8.6]
- Provide the capability to cancel Level 1 processing prior to completion of product generation. [FPRS 3.3.8.7]

Operations Support Requirements (Cont.)

- Coordinate resolution of data transfer problems with any LOR Product file with ECS. [FPRS 3.3.1.3]
  - Detect data transfer problems
  - Re-retrieve data
  - Notify ECS when data is ready for re-transfer

Performance Requirements

- Process a volume of data equivalent to 28 (- accounts for 10% reprocessing) standard L0R WRS scenes to Level 1 products each day. [FPRS 4.1.1]
- Contribute no greater than .7% uncertainty to absolute radiometric accuracy during the generation of Level 1 digital images. [FPRS 4.1.2]
- Contribute circular errors no greater than 1.8 meters, 1 sigma, in the production of systematically corrected L1G digital images. [FPRS 4.1.3]

Performance Requirements (Cont)

- The LPGS shall provide an accuracy of at least 250 meters cross track and 250 meters along track for Level 1 G products.
  [FPRS 4.1.8]

System Performance Requirements

- Provide at least 125% of the random access memory capacity required to satisfy the worst case memory loading.
  [FPRS 4.1.5]
- Provide at least 125% of the peripheral storage capacity required to satisfy the worst case peripheral storage loading.
  [FPRS 4.1.6]
- Provide at least 110% of the input/output band width required to satisfy the worst case input/output operations loading.
  [FPRS 4.1.7]
-
- Provide at least 110% of the processing throughput capability required to satisfy the worst case processor loading.
  [FPRS 4.1.4]

External Interface Performance Requirements

- Ingest a volume equivalent to 3 WRS scenes worth of standard L0R data for each Level 1 product request. [FPRS 4.2.1]
- Support the transfer to ECS the equivalent of a minimum of 25 Level 1 WRS sized digital images and associated metadata per day. [FPRS 4.2.2]
- Provide the capability to transfer the requisite daily volume of at least 33 Gbytes of output files to the ECS. [FPRS 4.2.3]

External Interface Requirements

- Provide interface with the ECS to receive: [FPRS 3.2.1]:
-
  - L0R files (includes associated PCD, MSCD, IC data, and Cal Parm file)
  - Level 1 image processing requests
  - Data availability notification
  - Production status requests
  - Product problem indicator(Trouble Ticket)
  - Cancellation Request

External Interface Requirements

- Provide interface with the ECS to coordinate the transfer of: [FPRS 3.2.2]
  - LPGS Level 1 digital images
  - Level 1 metadata
  - Processing status
  - Accounting information
  - L1 Processing statistics
-

External Interface Requirements(Cont.)

- Provide interface with the Image Assessment System (IAS) to deliver Level 1 characterization results. [FPRS 3.2.3]
- Provide interface with the Data Handling Facility(DHF) to provide Level 1 processing anomaly reports. [FPRS 3.2.4]

RMA

- The LPGS shall provide an operational availability of .95.(TBR) [FPRS 4.4.1]
- The LPGS shall support a mean time to restore (MTTR) capability of 16 hours. (TBR) [FPRS 4.4.2]

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Operations Concept

- Operations Concept
  - Data Volumes
  - External Interfaces
  - Nominal Operations
  - Contingency Operations

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Daily Data Volumes

- **Input**

Data	Interface	Volume
· L0R Product Image	ECS SDPS	14.9 GB/day
· Non-image product	ECS SDPS	1 GB/day
· L1 product generation request	ECS SDPS	< 100 MB/day
· Trouble Tickets	ECS MSS	< 100 MB/day
· L1 product cancellation request	ECS SDPS	< 100 MB/day
· L1 production status request	ECS SDPS	< 100 MB/day
· L1 product accounting information	ECS MSS	< 100 MB/day

- **Output**

Data	Interface	Volume
· L0R Product Request	ECS SDPS	TBD
· L1 Data (image, metadata, production quality summary)	ECS Insert Service	32.5 GB/day
· Characterization results	IAS	< 100 MB/day
· Anomaly Report	DHF	<100 MB/day
· L1 product accounting	MSS	<100 MB/day
· L1 production status information	ECS SDPS	< 100 MB/day

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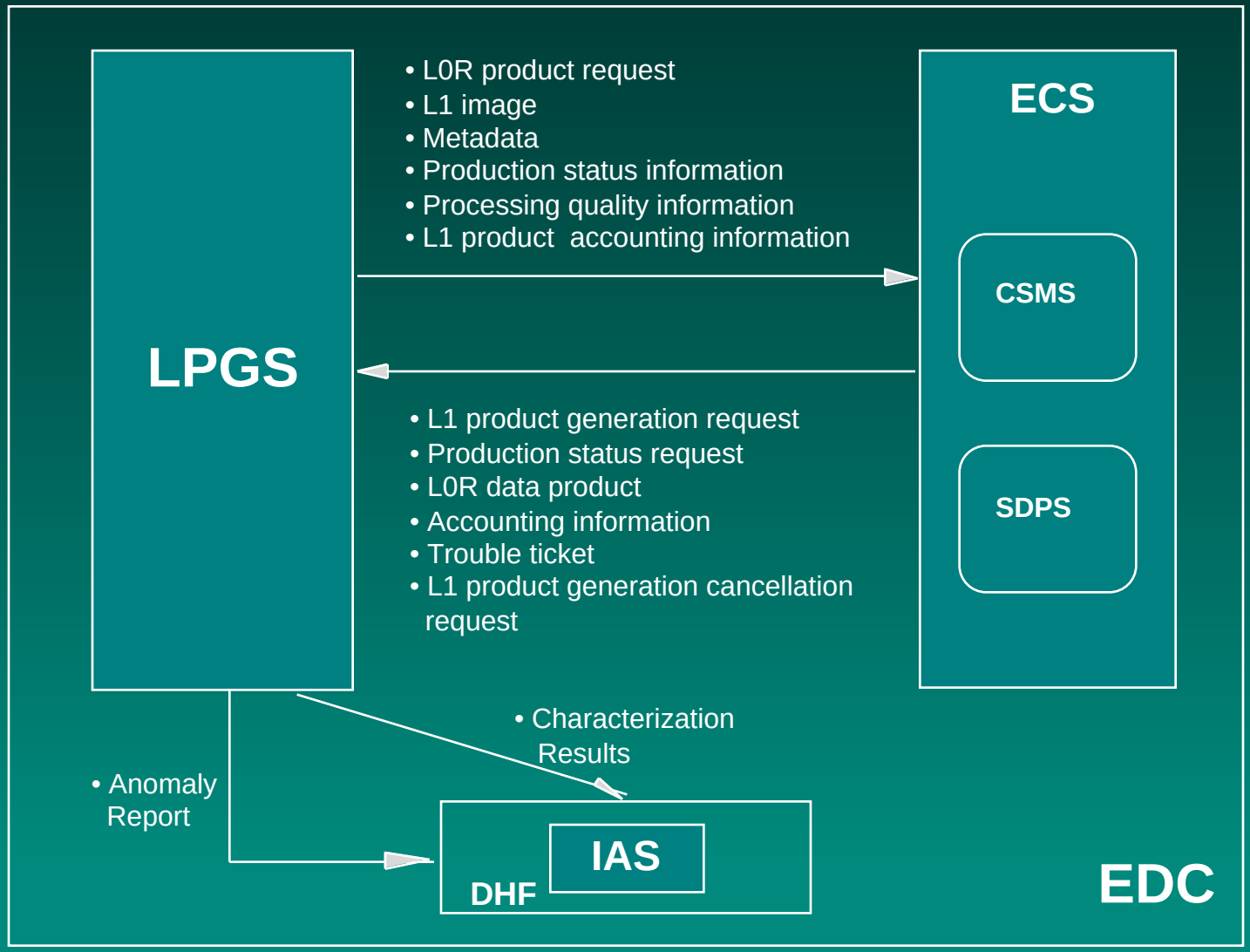
External Interfaces

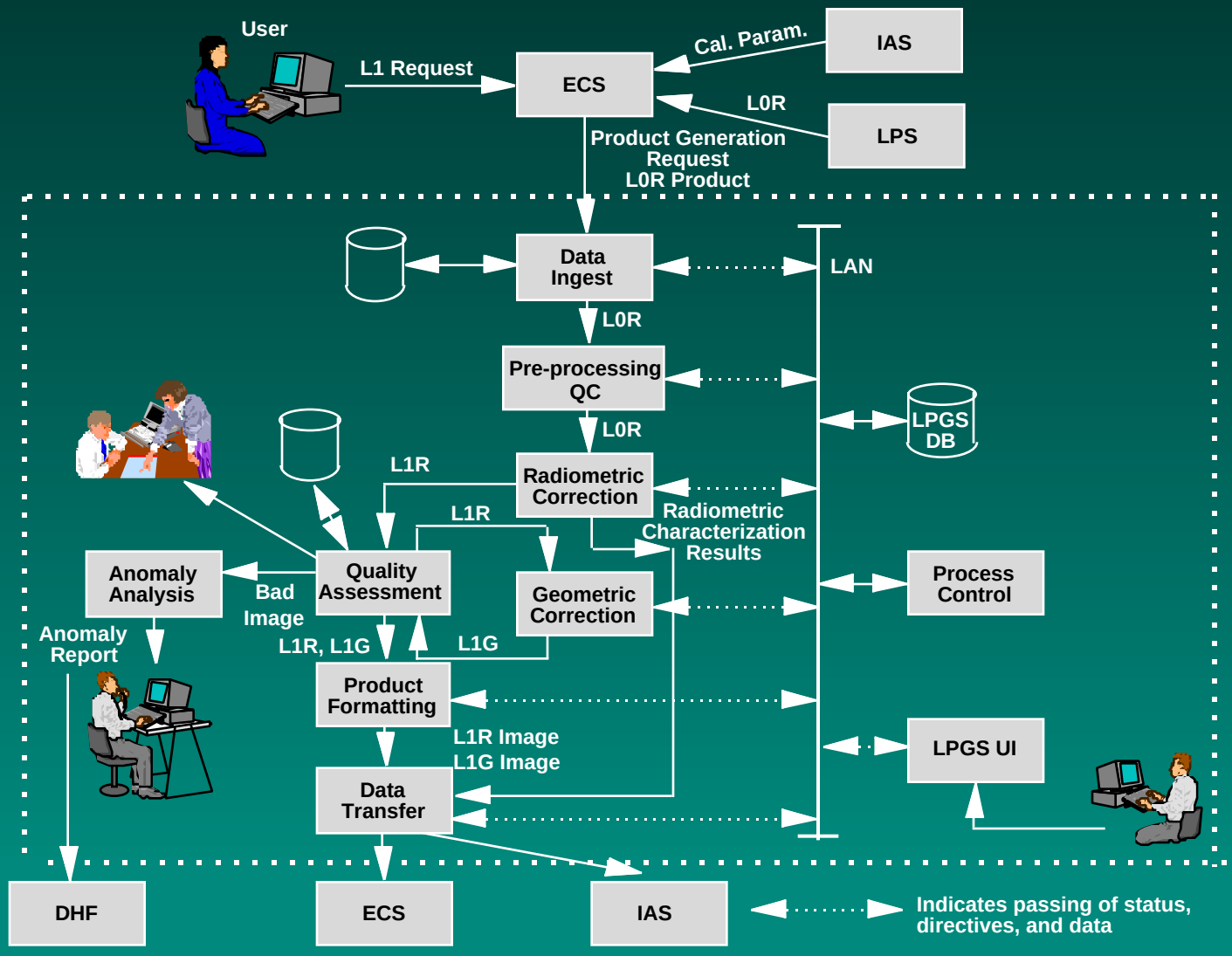


Nominal Operations

- Receive and queue L1 product requests
- Request and retrieve L0R data
- Generate L1 images
  - Radiometric Correction
  - Geometric Correction
- Stage and notify ECS of image ready for transfer
- Receive and transmit accounting information
- Resolve anomalies
- Update algorithms
- Maintain and test system

LPGS System Reqs/System Design Review

LPGS Processing Flow



Receive and queue L1 product requests

- Receive L1 product generation requests from ECS
  - Identify needed L0R product
  - Prepare L1 production work order
    - Incorporate user parameters
    - Include operator-specified thresholds and processing options
- Queue work order
- Production status provided in response to customer requests and operator directives
- Receive L1 product cancellation request
  - Identify L1 production work order
  - Terminate work order processing
- All work order and image processing and QA is automated and can be performed without human intervention

Request and retrieve L0R data

- Prepare L0R product request
  - Specify L0R products identified in work order
- Transmit L0R product request to ECS
- Receive notification from ECS that L0R products are available
- Retrieve L0R products
  - Extract L0R image
  - Extract appended files: PCD, MSCD, IC data, Calibration parameters file and metadata
- Update work order status to indicate all data needed for processing are available

Generate L1R Image

- Characterize radiometric effects
  - Locate radiometric artifacts in L0R image and internal calibrator data
- Correct for radiometric artifacts and determine effects of correction
- Output results of radiometric characterization
- Apply calibration parameter file gains and biases to convert image to absolute radiance
- Assess quality of L1R image and output processing quality info
- Provide processing status updates to work order
- Update metadata and output L1R image

Generate 1G Image

- Generate satellite geometric correction model
- Generate resampling grid based on customer-specified grid cell size
- Apply resampling techniques to L1R image
  - Place radiometric values in grid cell
  - User-specified resampling includes nearest neighbor, cubic convolution encoding, modulation transfer function
- Perform systematic correction using sophisticated satellite geometric correction model contained in algorithms
- Assess quality of L1G image and output processing quality info
- Provide processing status updates to work order
- Update metadata and output L1G image

Stage and notify ECS of image ready for transfer

- Format L1R image
  - HDF-EOS
- Format L1G image
  - HDF-EOS
  - GEOTIFF
  - FAST
- Stage L1R and L1G images, processing quality information and metadata for retrieval by ECS
- Notify ECS of availability of L1 images and associated data

Receive and transmit accounting information

- On a periodic basis prepare summaries of
  - Images received, produced, staged for distribution
  - Product generation requests received and successfully processed
  - Product cancellation requests received and processed
  - Anomalies resolved
- Provide accounting summaries to ECS

Resolve anomalies

- Receive trouble tickets from ECS or detect anomalies in images during quality assessment process
- Analyze anomalies found in L1 images
  - Use all available ancillary, image, characterization and calibration parameter data
  - Use tools also available to IAS
  - Off-line analysis does not impact production schedule
- Process benchmark or calibration scene to isolate problems with LPGS image processing s/w
- If unable to isolate problem in LPGS system, prepare anomaly report for distribution to DHF

Update algorithms

- Coordinated through s/w maintenance and sustaining engineering operations
- Algorithms updated without impacting production
  - Integrated into test baseline prior to operational use
  - Process calibration scene to verify processing quality
- Production baseline modified during off-peak hours
- Maintain common algorithm baseline with IAS

LPGS System Reqs/System Design Review

Maintain and test system

- Additional compute power added to LPGS subsystems to accommodate testing
- Benchmark images maintained to support anomaly resolution and regression testing

Contingency Operations

- LPGS Failure
  - Failure of any LPGS subsystem
    - EDC DAAC user services notified by voice or e-mail
    - Operations procedures followed to isolate, resolve and recover from failure with least impact on production
    - Processing estimates and production status updates provided to EDC DAAC user services and ECS
- Failure of Communications Links to ECS
  - Notify ECS system operator by voice
  - Operations procedures followed to isolated failed link
  - Production continues as much as possible until staging backlog exceeds available temporary storage
  - Data held in temporary storage until communications reestablished and verified

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- Operations Concept
- **System Design**
- Conclusion

System Design

- System Architecture
- Hardware Architecture
- Software Architecture

Design Drivers

- Provide L1R and L1G processing in support of the EGS
- Maintain system and operations cost and development schedule objectives
  - Minimize impact to ECS
- Reduce risks
- Employ L1 processing algorithms being developed for IAS
- Maximize throughput and provide flexibility for expansion

System Architecture - Assumptions

- The Level 1 geometric and radiometric processing subsystems will be available for integration by LPGS
- EGS components will be available for use by LPGS
  - ECS for all interaction with the user and packaging of final Level 1 product
  - EBnet for network and communications services
- The LPGS will not perform precision or terrain correction for ground control points during L1G production. It will, however, perform resampling for geometric correction and geographic registration to map projections.

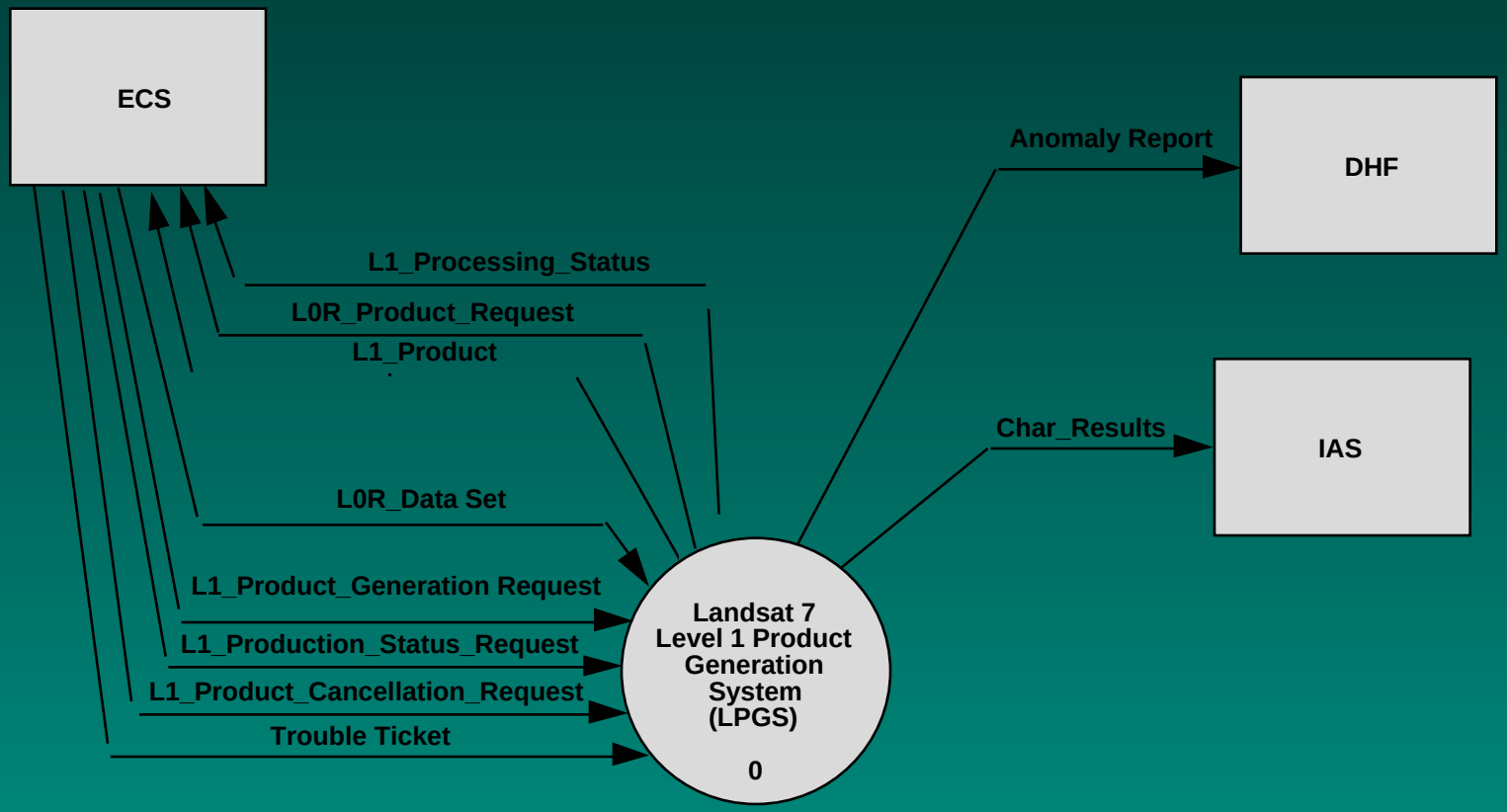
System Architecture

Developed by

- Evaluating IAS system architecture
  - Reuse of
    - IAS processing software
    - IAS analysis tools
  - Reduces cost, development time
  - Enables cross-training of personnel
- Modifying IAS system architecture to:
  - Accommodate higher throughput requirements
  - Support pipeline processing (as opposed to analysis)
- Ensuring compatibility with other EGS components

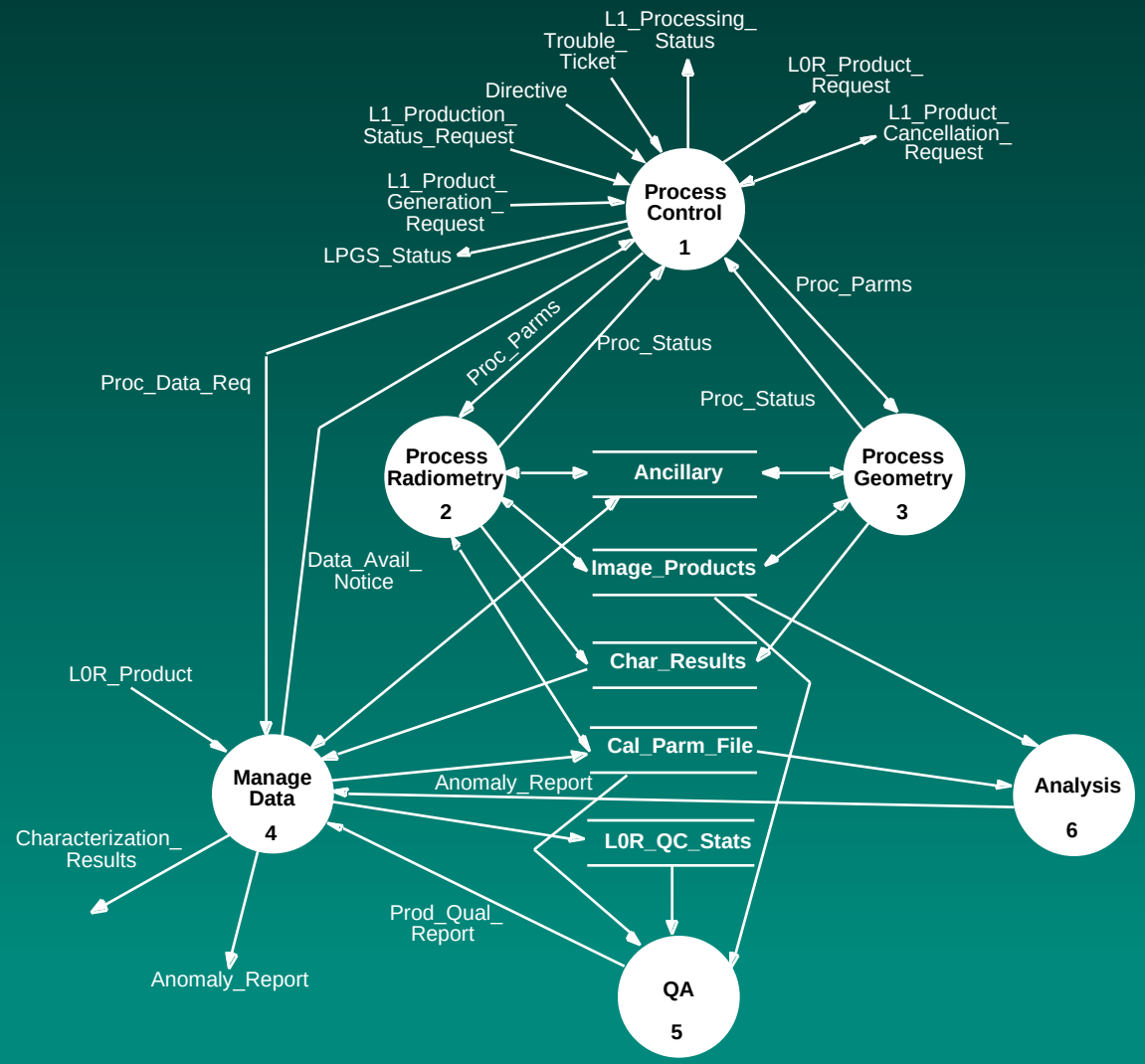
LPGS System Reqs/System Design Review

System Architecture - LPGS Context Diagram



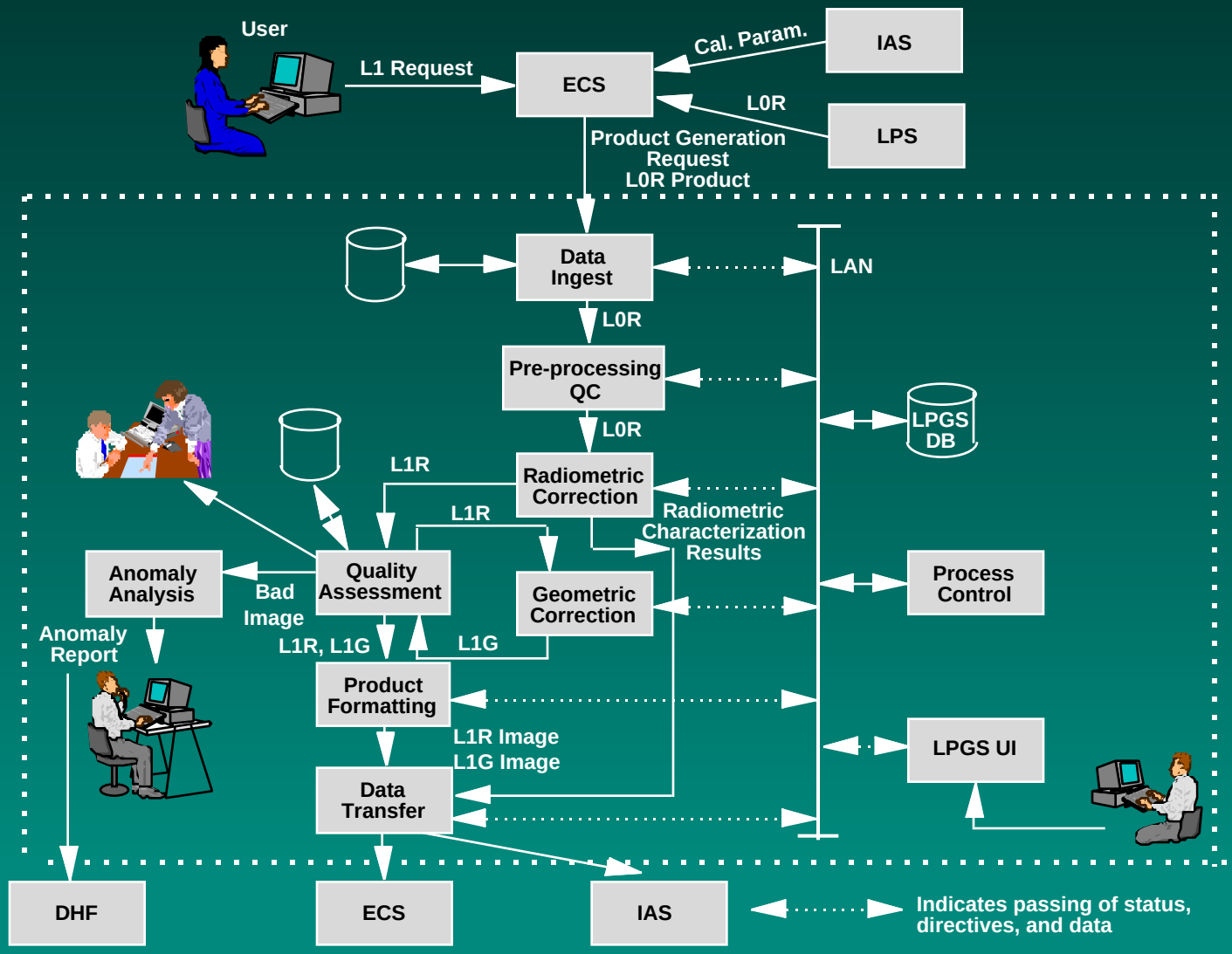
LPGS System Reqs/System Design Review

System Architecture - Level 0 Data Flow Diagram



LPGS System Reqs/System Design Review

LPGS Processing Flow



Hardware Architecture - Assumptions

PERFORMANCE AND SIZING ASSUMPTIONS

- Minimum volume per product = 1 full WRS scene equivalent
- LPGS must be able to accommodate scenarios where 100% of the requests are for processing data equivalent to 3 contiguous L0R scenes to L1G
- Internal calibrator data and calibration parameter file are
  - Included in each L0R product request
  - Not returned to ECS for distribution with LPGS-generated output
- Requests to be worked off in a sequential manner over the entire 24 hour day
  - No more than one request at a time will be in each processing step
  - No step to take longer than 50 minutes for each scene in the request
  - Visual quality assessment to occur only on prime shift
- Equivalent data storage for one L0R scene:

Data Type	L0R	Cal	L1R	L1G
GB/scene	0.5	0.041	1.3	1.3

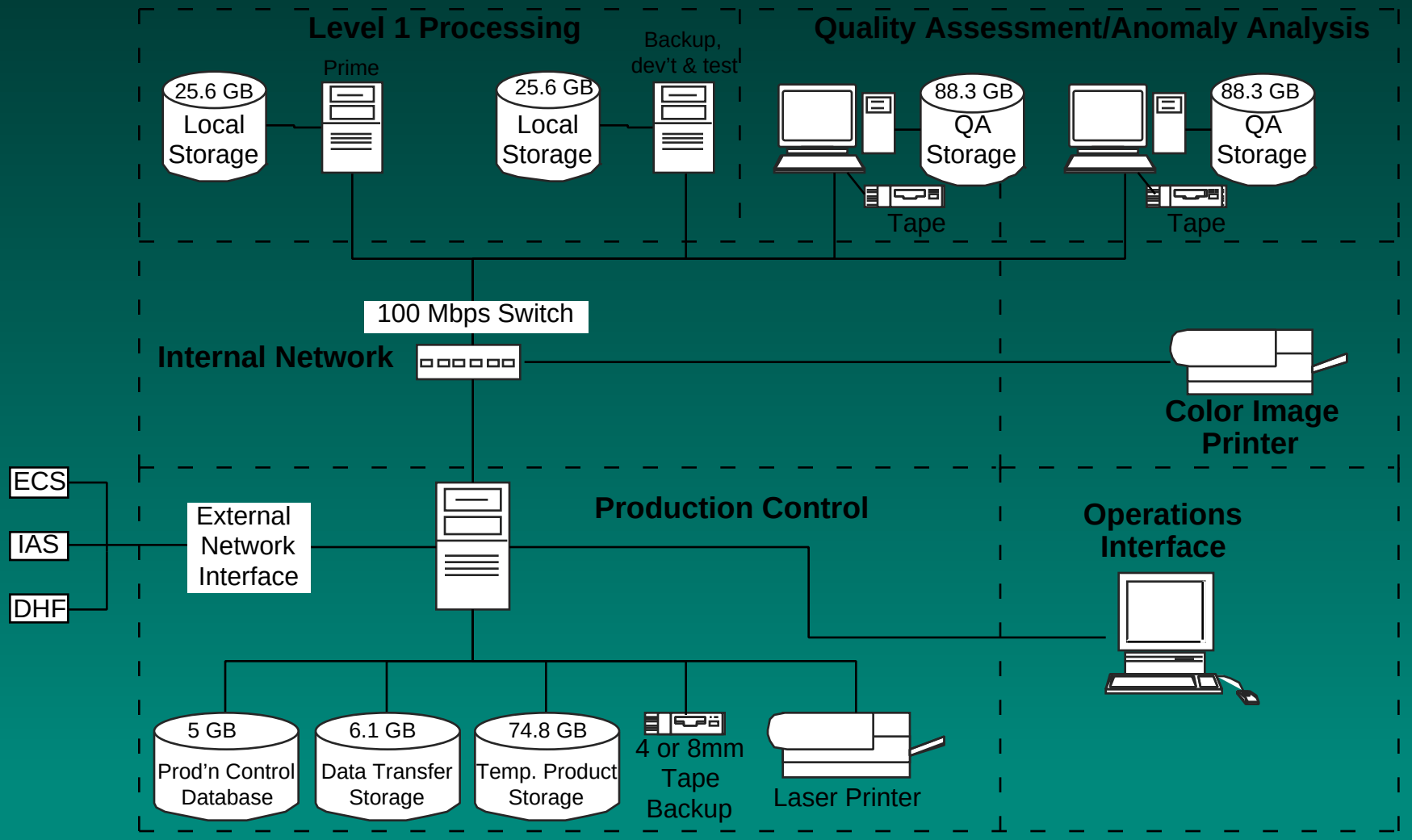
Hardware Architecture

Developed by

- Starting with IAS hardware architecture
- Modifying IAS hardware architecture to:
  - Accommodate internal network throughput required for higher volume requirements
  - Accommodate the data flow management required for transferring data to/from ECS for production processing

LPGS System Reqs/System Design Review

Hardware Architecture



Hardware Architecture

- Hardware Configuration Items (HWCIs)
  - Production Control
  - Level 1 Processing
  - Quality Assessment/Anomaly Analysis
  - Internal Network
  - Operations Interface
  - Color Image Printer

Hardware Architecture - *HWCIs (1 of 6)*

PRODUCTION CONTROL

- Functions
  - Provides storage for incoming and outgoing data and for the PC database
  - Serves as network gateway interface with external entities
- Components
  - Network server with 2 boxes or 1 box with hot swappable component
  - On-line storage using RAID technology (~90 GB)
  - Dual network connection (TBD/internal, FDDI/external)
  - Tape drive
  - Black and white laser printer
- Platform TBD
  - No transfer to take more than 50 min. per L0R scene
  - Selection of platform, CPU and memory to be based on benchmark of data transfers in a network environment similar to that expected for LPGS

Hardware Architecture - *HWCIs (2 of 6)*

LEVEL 1 PROCESSING

- **Functions**
  - **Performs science data processing**
  - **Provides compute power and local storage needed to process L0R images to L1R and L1G**
- **Components**
  - **Set of redundant compute servers (two or more)**
  - **Local storage (25.6 GB * # of compute servers = 51.2 GB minimum)**
    - **Input L0R image w/ corresponding cal data, output L1 data**
- **Platform TBD pending IAS selection**
  - **Expect differences in the configuration and number of platforms due to production vs. analysis requirements**

Hardware Architecture - *HWCIs (3 of 6)*

QUALITY ASSESSMENT/ANOMALY ANALYSIS

- Functions
  - Visual assessment of processed data
  - Investigation of processing anomalies
- Components
  - At least two display workstations
    - 4mm DAT for off-loading problem images
  - Local storage (~88.3 GB per workstation)
    - Images to be visually inspected or images that experienced anomalies during science processing
- Platform TBD pending IAS selection
  - Hope to reuse analysis tools

Hardware Architecture - *HWCIs (4 of 6)*

INTERNAL NETWORK

- **Functions**
  - **Provides all of the network communications between the LPGS HWCIs**
  - **Isolated from external traffic by the gateway on the Production Control HWCI**
- **Components**
  - **100 Mbps Ethernet network (100BaseT) in a star configuration**
    - **Center of the star is an Ethernet switch**
    - **Each connection from the switch will be to an individual platform**

Hardware Architecture - *HWCIs (5 of 6)*

OPERATIONS INTERFACE

- **Functions**
  - **Provides a text and graphical interface for the production control operator**
- **Components**
  - **XWindows capable color monitor and keyboard**
    - **Connected to console ports of the Production Control HWCI**

Hardware Architecture - *HWCIs (6 of 6)*

COLOR IMAGE PRINTER

- **Functions**
  - **Provides a hardcopy interface for producing color prints of processed data for quality analysis**
- **Components**
  - **Color printer [TBD] based on requirements for resolution needed to use output for analysis**

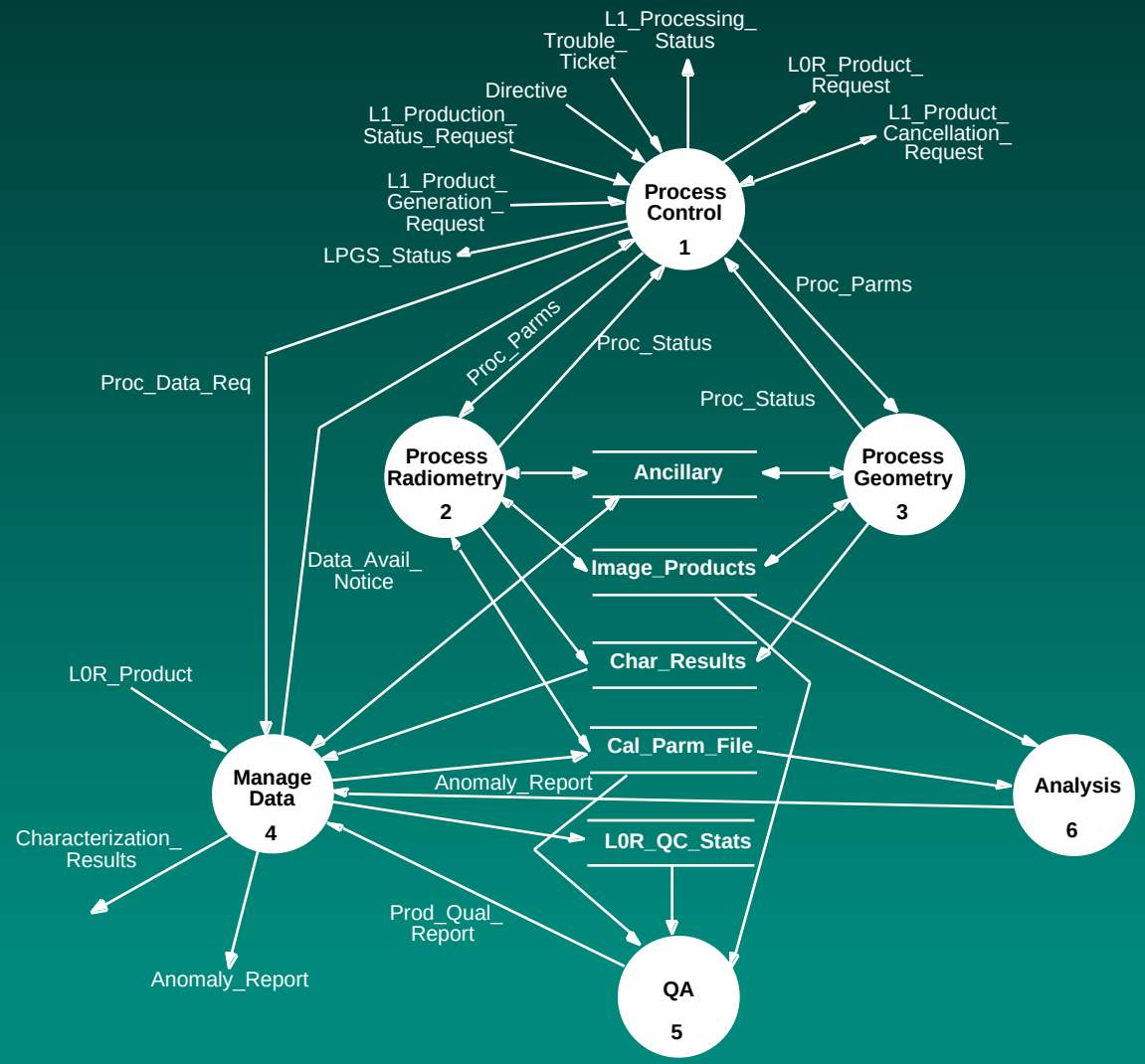
Software Architecture

Developed by

- Starting with IAS subsystem definitions
- Modifying IAS software architecture to accommodate requirements of production system
- Decomposing LPGS functional requirements
- Evaluating architecture based on
  - Coupling (strength of association between LPGS subsystems)
  - Cohesion (strength of association of elements within each LPGS software subsystem)
  - Reuse
- Repartitioning subsystems and reevaluating until architecture satisfactorily meets criteria

LPGS System Reqs/System Design Review

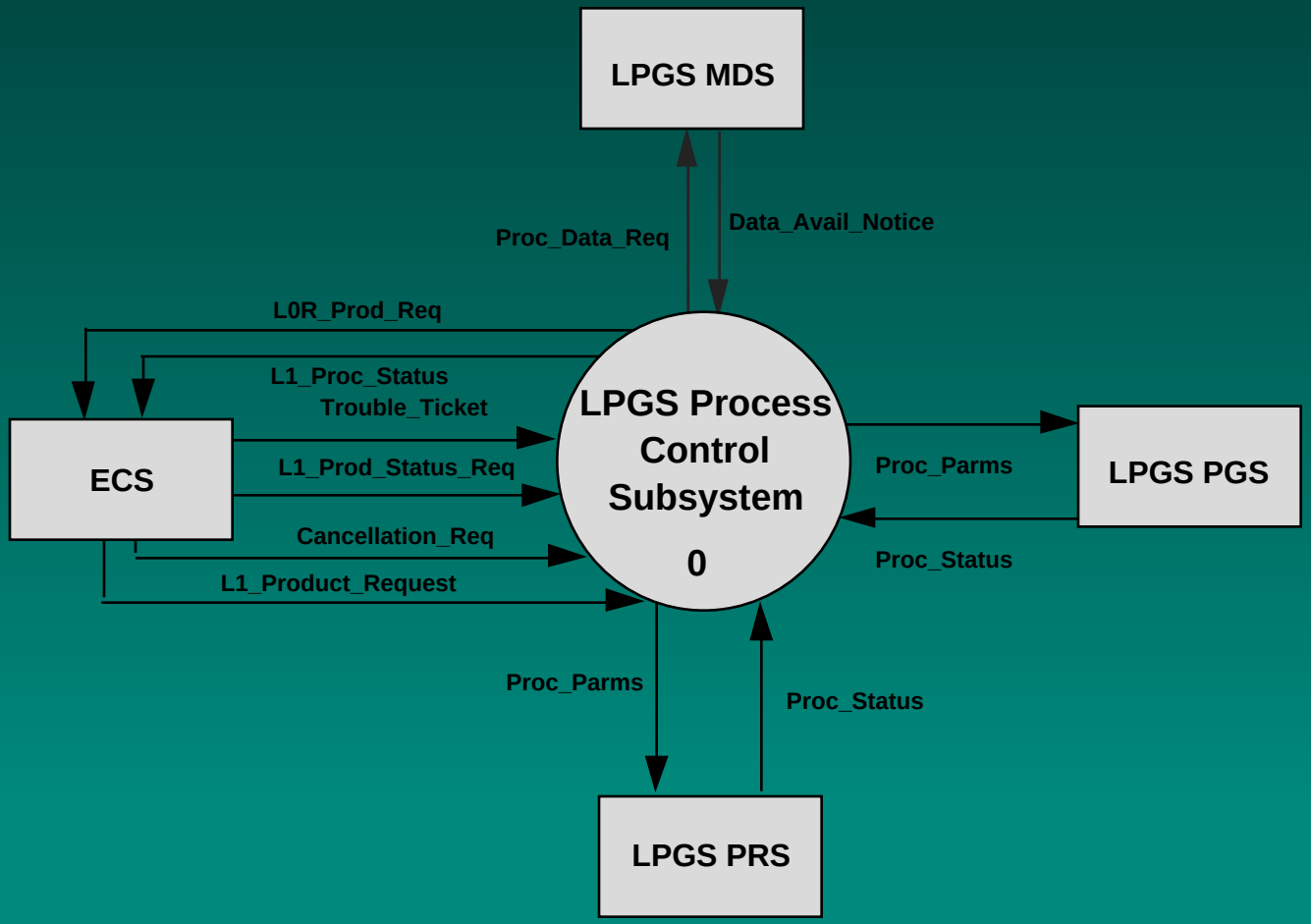
Software Architecture - *Level 0 Data Flow Diagram*



S/W Architecture - *Applications S/W Subsystems*

1. Process Control Subsystem (PCS)
2. Process Radiometry Subsystem (PRS)
3. Process Geometry Subsystem (PGS)
4. Manage Data Subsystem (MDS)
5. Quality Assessment Subsystem (QAS)
6. Anomaly Analysis Subsystem (AAS)

Process Control Subsystem (PCS) Context Diagram



Process Control Subsystem (PCS):

Controls LPGS production planning and scheduling

Input (Source)	Output (Destination)
Requests: L1 product generation (ECS) L1 production status (ECS) Cancellation (ECS)	Requests: L0R product (ECS) Process data - start work order (MDS)
Data availability notice (MDS)	L1 process status - prod'n schedule (ECS)
Trouble ticket (ECS)	Processing parameters (PRS, PGS)
Process status (PRS, PGS)	

S/W Architecture - *Applications S/W Subsystems*

Process Control Subsystem (PCS):

Setup Work Order

- Set up work orders for requested Level 1 products

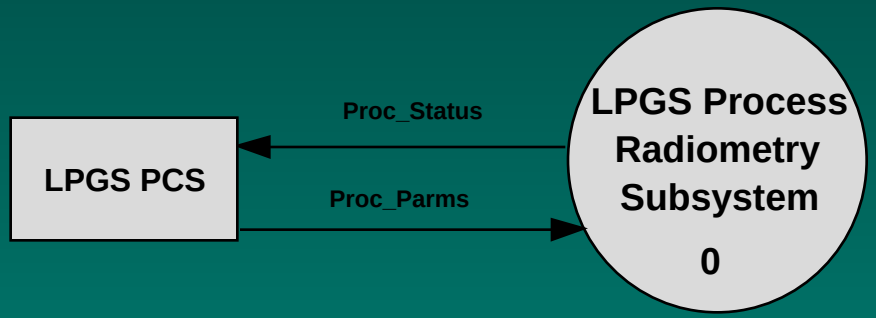
Control Processing

- Respond to ECS-provided production requests
- Schedule work order requests
- Control the execution of the work orders

Manage LPGS Resources

- Manage and monitor LPGS resources

Process Radiometry Subsystem (PRS) Context Diagram



S/W Architecture - *Applications S/W Subsystems*

Process Radiometry Subsystem (PRS):

Perform Radiometric Characterization

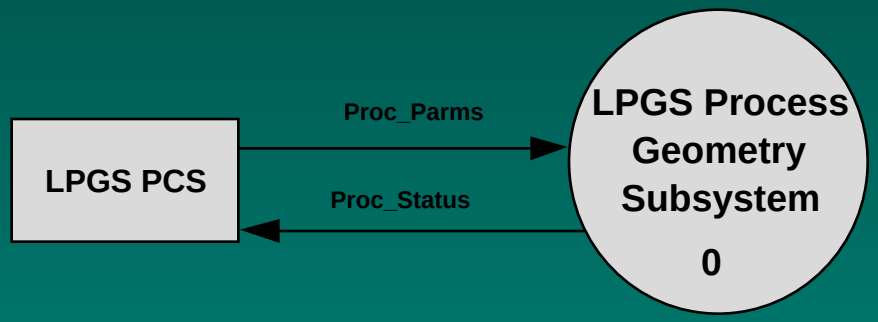
- **Provide results of characterizations performed and processing status for use by external elements and other LPGS subsystems**

Perform Level 1R Processing

- **Converts the brightness of the L0R image pixels to absolute radiance**

Input (Source)	Output (Destination)
Processing parameters (PCS)	Process status (PCS)

Process Geometry Subsystem (PGS) Context Diagram

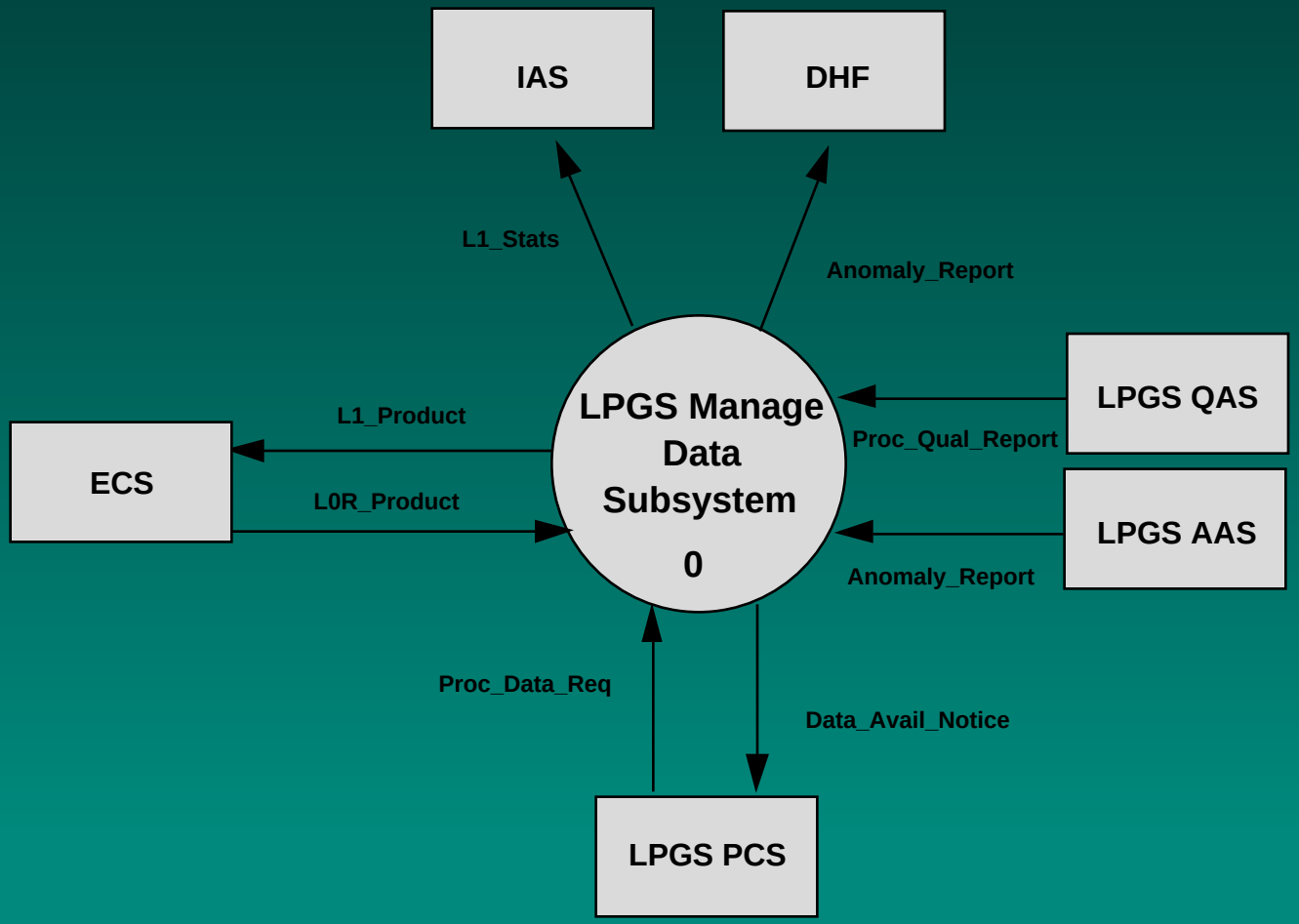


Process Geometry Subsystem (PGS):

Create systematically corrected L1G imagery from L1R images

Input (Source)	Output (Destination)
Processing parameters (PCS)	Process status (PCS)

Manage Data Subsystem (MDS) Context Diagram



Manage Data Subsystem (MDS):

Maintains and provides access to LPGS data stores

Input (Source)	Output (Destination)
Process data request (PCS)	Data availability notice (PCS)
L0R product (ECS)	L1 output data (ECS)
Process quality report (QAS)	L1 characterization results (IAS)
Anomaly report (AAS)	Anomaly report (DHF)

Manage Data Subsystem (MDS):

Data Ingest

- Handle communication protocols with external data sources
- Ingest externally provided files and format them for LPGS use

Level 0R Data Quality Check

- Perform cursory quality checks (verify all files are related to the same time period and subinterval, verify L0R image is a suitable candidate for L1 processing)

Format/Package Product

- Format/package Level 1 output and processing reports

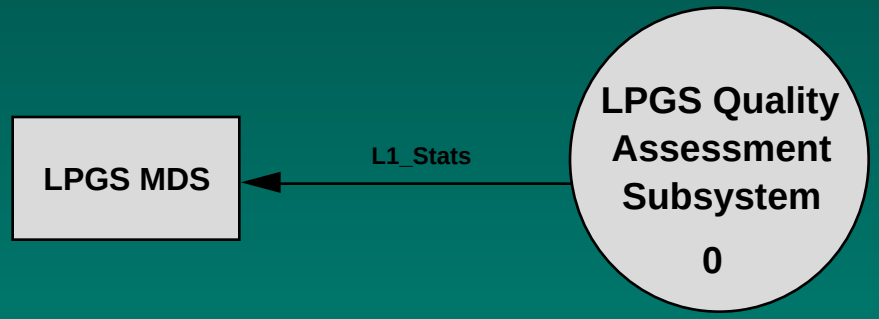
Data Transfer

- Distribute files to external interfaces

Manage Disk Space

- Traditional file management services including backups, disk space management, managing data stores, etc.

Quality Assessment Subsystem (QAS) Context Diagram



Quality Assessment Subsystem (QAS)

Assess Quality of Level 1 Image

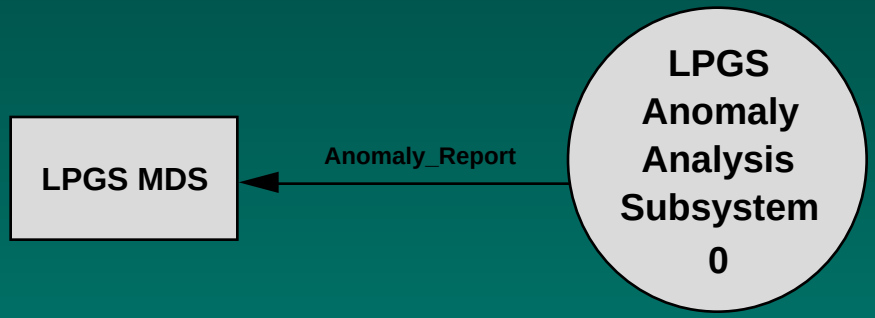
- Generate and assemble post-production information about the image artifacts and effects which were not corrected

Format Processing Quality Information

- Produce a summary of the processed image quality

Input (Source)	Output (Destination)
	Process quality report (MDS)

Anomaly Analysis Subsystem (AAS) Context Diagram



Anomaly Analysis Subsystem (AAS)

Analyze Anomalies Detected

- **Analyze L1 images and associated post-production information about image artifacts and effects to resolve image production anomalies**

Generate Anomaly Report

- **Produce a report of the analysis and resolution of image anomalies**

Input (Source)	Output (Destination)
	Anomaly report (MDS)

Allocation of HWCIs to Applications Subsystems

HWCI	Process Control (PCS)	Process Radiometry (PRS)	Process Geometry (PGS)	Quality Assessment (QAS)	Anomaly Analysis (AAS)	Manage Data (MDS)
Production Control	X					X
Level 1 Processing		X	X	Automatic		
Quality Assessment/ Anomaly Resolution				Manual	X	
Operations Interface	X					
Internal Network	X					X
Color Image Printer				X	X	

Software Architecture - System/COTS Software

Software Configuration Items (SWCIs) are TBD pending the selection of the HWCIs

SYSTEM SOFTWARE:

- IRIX Operating System
- Add-On Device Driver Support
- RAID Device Interface

COTS SOFTWARE:

- Oracle DBMS
- NCSA HDF support software
- HDF-EOS support software
- GeoTIFF support software
- FAST support software
- Job scheduling software
- Image display and analysis software

Remaining Work/Issues

- Complete RMA analysis
- Resolve TBD items
- Perform analysis on number of products vs. output volume
- Perform additional analysis on hardware alternatives
  - Performance of network server vs. amount of local storage needed
- Ensure consistency of terms (DFD terms, etc.) with IAS

LPGS System Reqs/System Design Review

Agenda

- Introduction
- System Concept
- Requirements
- Operations Concept
- System Design
- Conclusion

Conclusion

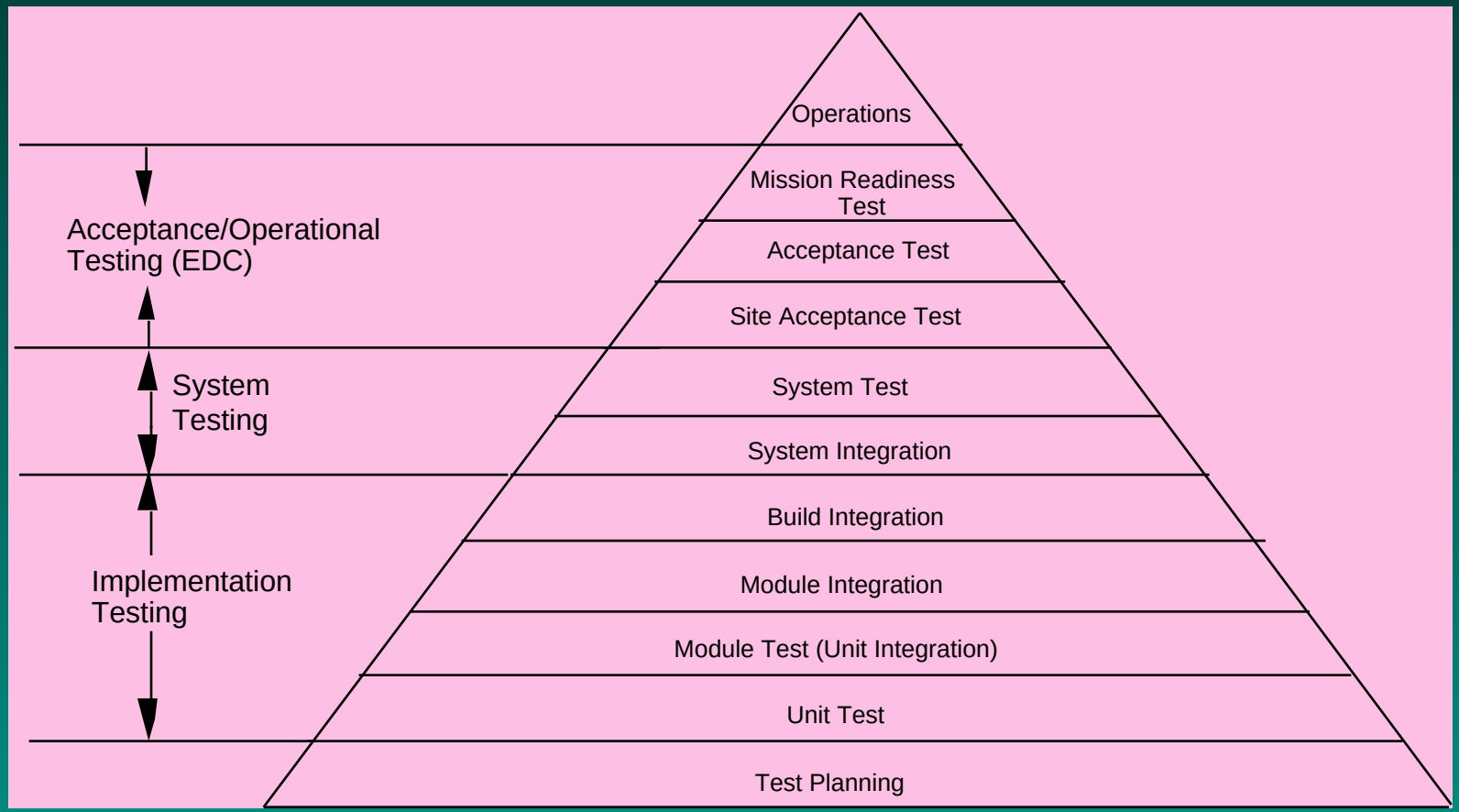
- Development Approach
- System Integration and Test Approach
- Issues/Risks/Concerns
- Road to CDR
- Schedule

Development Approach

- Methodology
  - Classic Waterfall - tailored to meet LPGS project goals and needs
- Development Environment
  - Software
    - CASE Tools (CADRE, RTM, ICAS)
      - Reuse of licenses currently available on our site license plan
    - Unix Operating System (IRIX)
    - ANSI C, POSIX wherever possible
    - ORACLE DBMS
  - Hardware
    - SGI platforms
      - Facilitates compatibility with the IAS for reuse
- Maximize use of COTS software and hardware
- Prototypes as necessary to clarify requirements or verify design concepts. User interface prototypes will be developed during design
- Participation by operations personnel in design process

LPGS System Reqs/System Design Review

System Integration and Test Approach



LPGS System Reqs/System Design Review

Test Approach

- Test Plans and Test Data Requirements developed during Preliminary Design Phase
- Algorithm Implementation Teams will provide subsystems which have been verified to meet requirements allocated to that subsystem. LPGS System Test team will be involved in this verification.
- EDC will participate in System Test activities at GSFC (similar to the LPS) resulting in Consent to Ship
- Installation and Checkout performed by GSFC
- Site Acceptance Test and any other Acceptance Tests at EDC to be conducted by EDC
- Engineering versions of test and analysis tools will be provided

Configuration Management

- Insuring System Integrity
  - Separate environments for development, integration test, system test, operations, and maintenance
  - Access Control
    - User IDS/Passwords for each environment
    - Write protected SW outside of the development environment
  - Configuration Item List
    - Track CIs, versions by environments
  - CMO only allows changes approved via formal configuration control process
    - Utilizing ICAS (IPD CCR Automation System) for change control
    - Utilizing PVCS for software configuration

Issues

- Documentation Issues
  - ESDIS Mission Specific Requirements for L7 Level 1 Processing not baselined, and IAS Interface not in L7 Level 2 Documentation
    - Working on baselining these items through the appropriate CCB actions

LPGS System Reqs/System Design Review

Risks

- Development Schedule
  - The LPGS is a late start development item. There will be difficulty meeting mission data availability
  - Mitigation: Continue to look for cost effective and schedule effective reuse opportunities both within the L7 Project, MTPE, and other vendors
- ECS Replan Schedule for Functionalities
  - ECS is in the process of replanning ECS Releases. LPGS assumes that all functionalities to be provided by ECS will be provided on an acceptable schedule. LPGS is not undertaking any individual element risk mitigation or contingency planning activities
  - Mitigation: LPGS will participate in any Landsat 7 Project level contingency planning and risk mitigations

Risks

- Transition to Operations and Maintenance Organization
  - Given the LPGS late start and hence development schedule, there is insufficient time to properly transition sustaining engineering responsibilities to the O&M organization. If sufficient transition is not provided the system cannot be properly maintained
  - Mitigation: Work with appropriate L7 Project personnel to provide support for maintenance and transition after L+90 days

LPGS System Reqs/System Design Review

Concerns

- Requirements Creep Concern
  - Design to Cost System
  - Careful control of requirements and costing estimates throughout project

LPGS System Reqs/System Design Review

Road to CDR

- LPGS Critical Design Review scheduled for July 1997
  - Develop appropriate interface (internal and external) documentation
  - Refine operational scenarios
  - Decompose software requirement dataflow diagrams as necessary
  - Complete any COTS package evaluations
  - Produce the LPGS Design
  - Produce the LPGS Output Data Files documentation
  - Finalize LPGS hardware modeling and analysis
  - Procure development and operational hardware systems

LPGS System Reqs/System Design Review

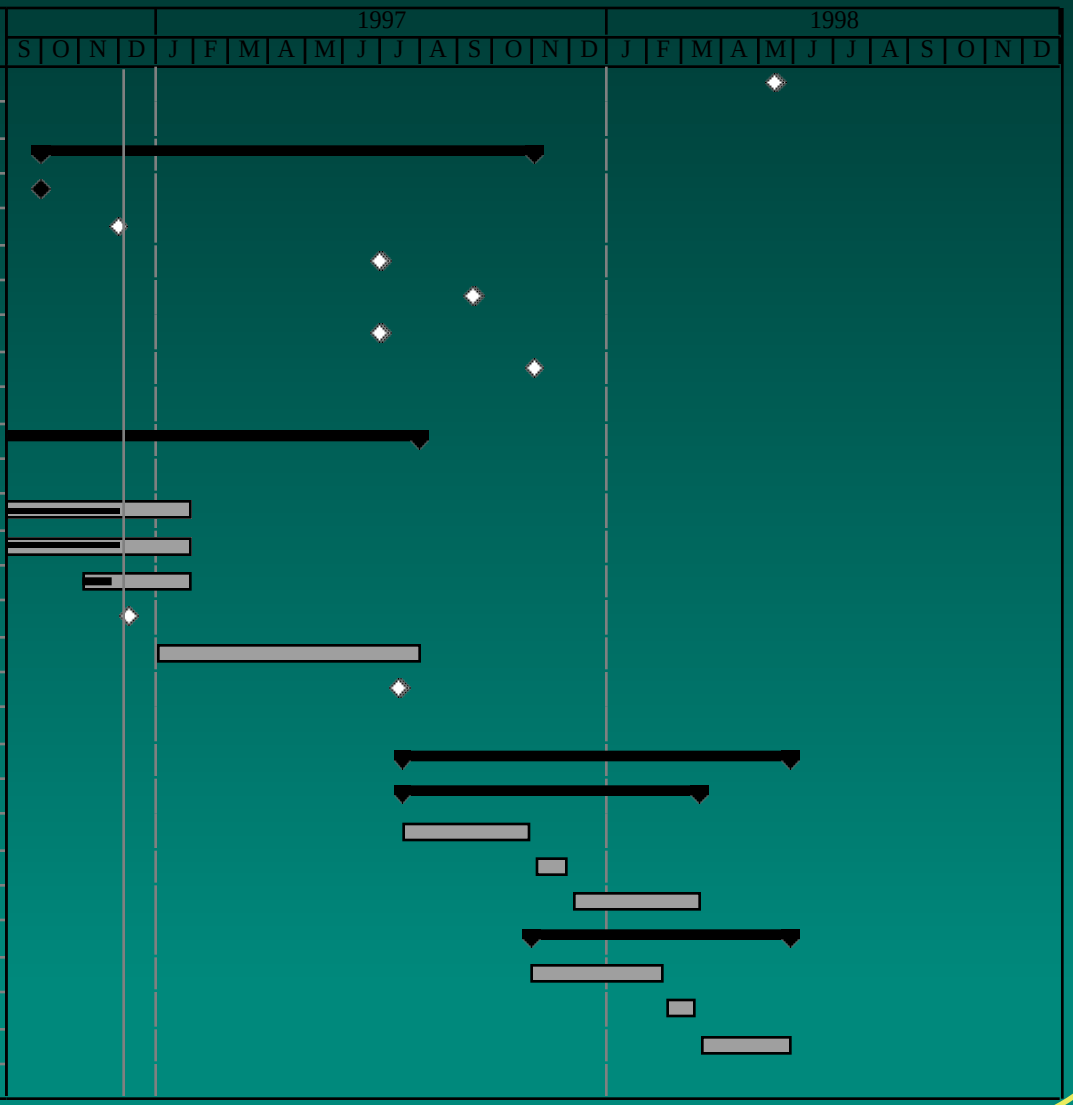
Schedule

- Schedule Highlights
  - System Requirements/System Design Review conducted in December 1996
  - Critical Design Review conducted in July 1997
  - Ready for shipment to EDC in May 1998

LPGS System Reqs/System Design Review

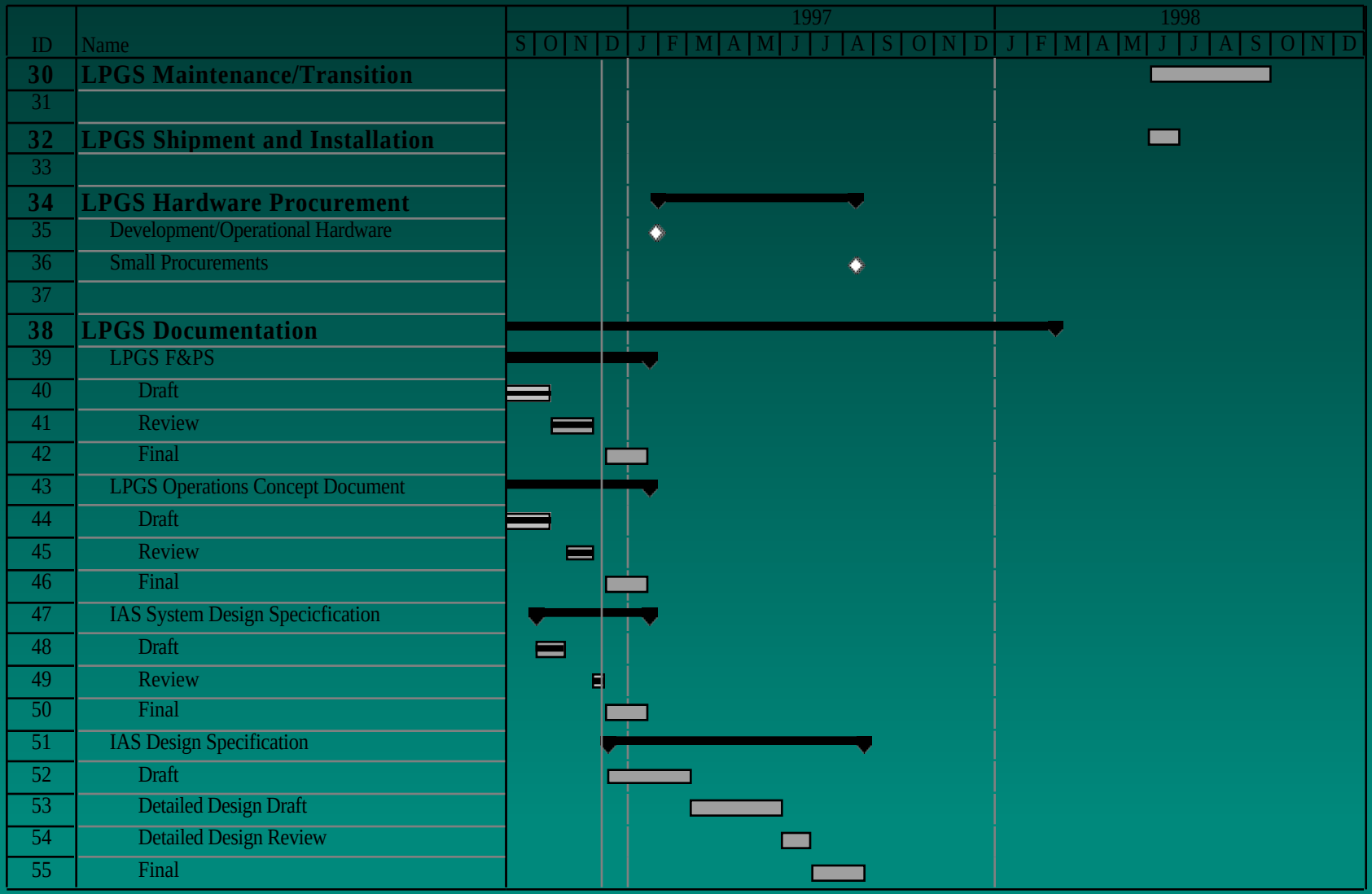
Schedule

ID	Name
1	**Landsat 7 Launch**
2	
3	**Algorithm Deliveries**
4	Radiometry R1 Descriptions Baselined
5	Radiometry R2 Descriptions Baselined
6	Geometry Release 1
7	Geometry Release 2
8	Radiometry Release 1
9	Radiometry Release 2
10	
11	**System Development**
12	
13	LPGS Requirements Analysis
14	LPGS Operations Concept Definition
15	LPGS System Design Phase
16	**LPGS SRR/SDR**
17	LPGS Design
18	**Critical Design Review**
19	
20	**LPGS Implementation**
21	LPGS Release 1
22	Implementation
23	Integration
24	System Test
25	LPGS Release 2
26	Implementation
27	Integration
28	System Test
29	



LPGS System Reqs/System Design Review

Schedule

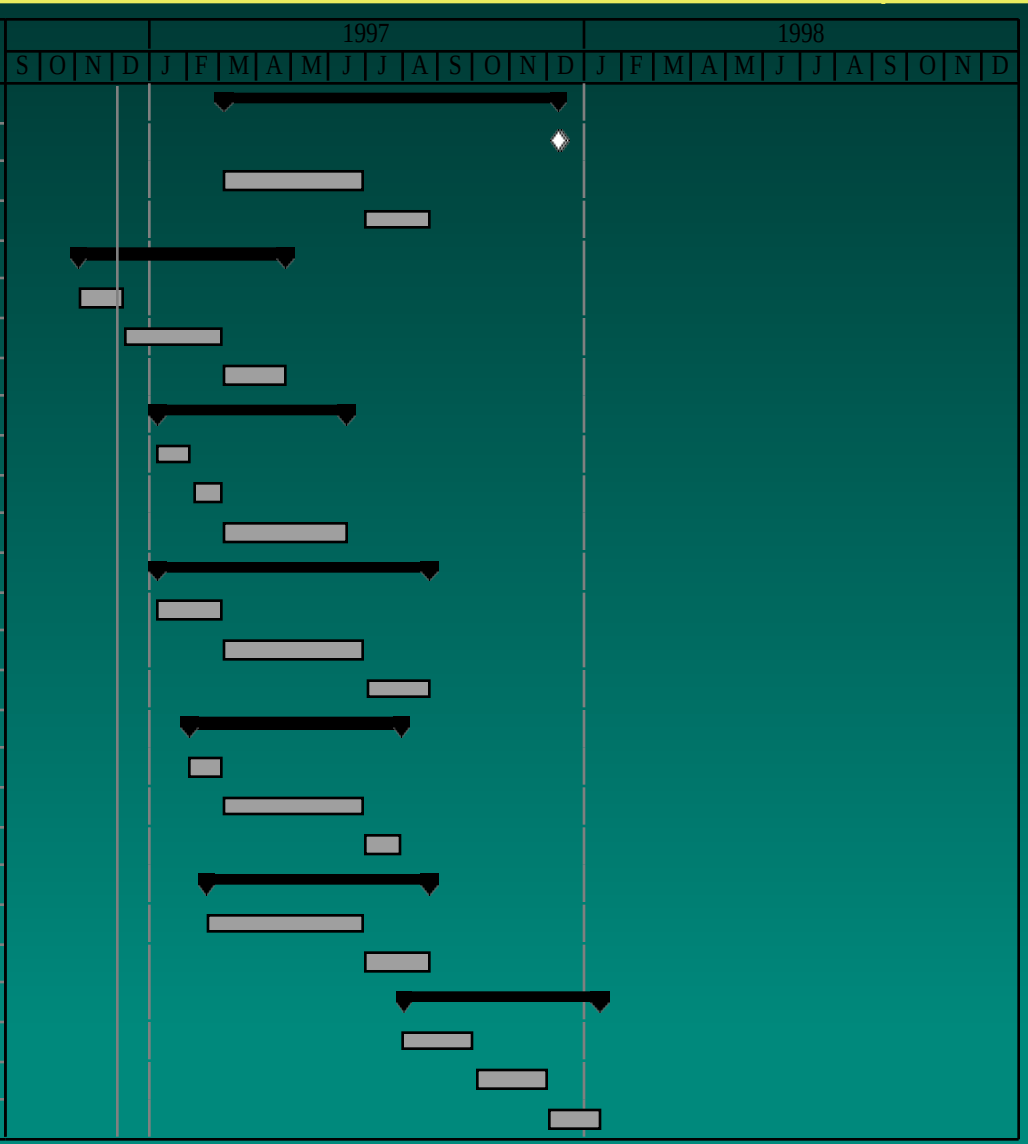


ID	Name
30	**LPGS Maintenance/Transition**
31	
32	**LPGS Shipment and Installation**
33	
34	**LPGS Hardware Procurement**
35	Development/Operational Hardware
36	Small Procurements
37	
38	**LPGS Documentation**
39	LPGS F&PS
40	Draft
41	Review
42	Final
43	LPGS Operations Concept Document
44	Draft
45	Review
46	Final
47	IAS System Design Specicfication
48	Draft
49	Review
50	Final
51	IAS Design Specification
52	Draft
53	Detailed Design Draft
54	Detailed Design Review
55	Final

LPGS System Reqs/System Design Review

Schedule

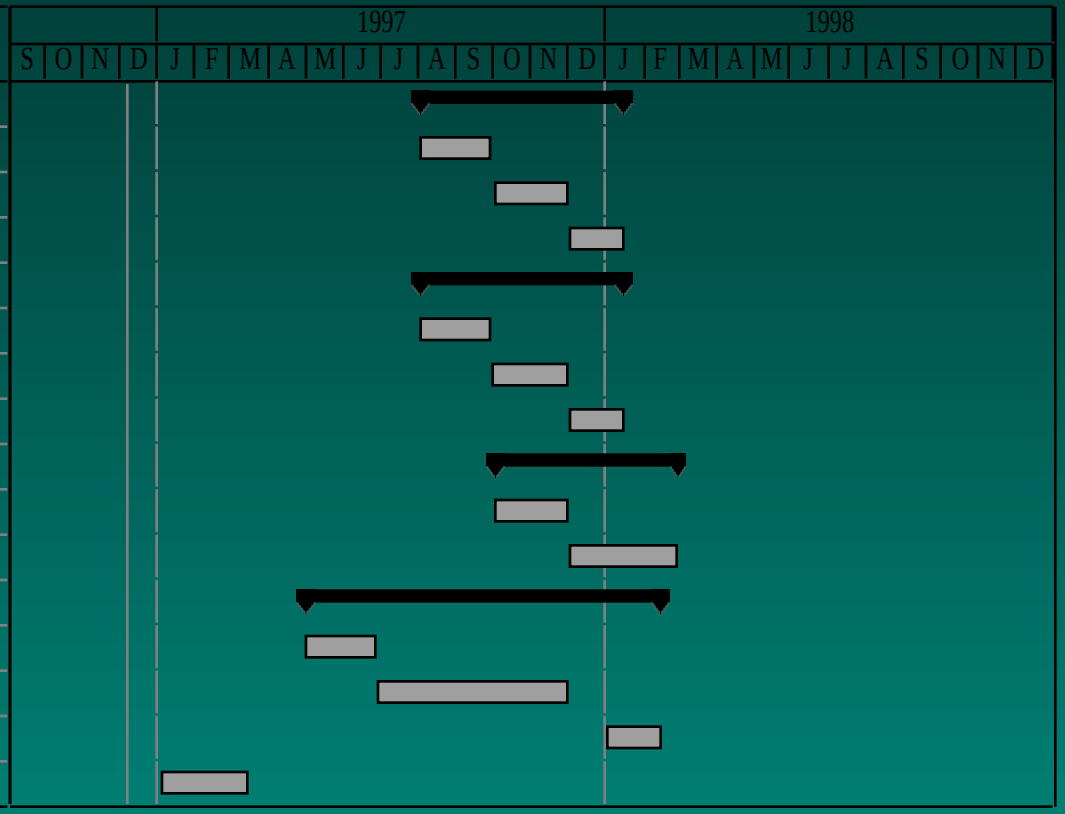
ID	Name
56	IAS Interface Definition Document
57	Draft
58	Review
59	Final
60	IAS /LPGS ICD (IAS provided)
61	Draft
62	Review
63	Final
64	ECS/LPGS ICD (ECS Provided)
65	Draft
66	Review
67	Final
68	LPGS DFCB
69	Draft
70	Review
71	Final
72	LPGS Build/Release Plan
73	Draft
74	Review
75	Final
76	LPGS System Integration and Test Plan
77	Review
78	Final
79	LPGS Transition Plan
80	Draft
81	Review
82	Final



LPGS System Reqs/System Design Review

Schedule

ID	Name
83	LPGS Installation Plan
84	Draft
85	Review
86	Final
87	LPGS Operations and Maintenance Manual
88	Draft
89	Review
90	Final
91	LPGS Programmer's Reference Manual
92	Draft
93	Review
94	LPGS System User's Guide
95	Detailed Design Draft
96	Release 1 Update Draft
97	Release 2 Final
98	LPGS GSFC/EDC MOU for S/W Development



LPGS System Reqs/System Design Review

Acronyms

AAS	Anomaly Analysis Subsystem
API	applications programming interface
cNMOS	consolidated Network and Mission Operations Support
COTS	commercial off-the-shelf
CPU	central processing unit
DAAC	Distributed Active Archive Center
DAT	digital audio tape
DBMS	Database Management System
DD	data dictionary
DDE	data dictionary entry
DFD	data flow diagram
DHF	Data Handling Facility
ECS	EOSDIS Core System
EDC	EROS Data Center
EGS	EOS Ground System
EOS	Earth Observing System
EOSAT	Earth Observation Satellite Company
EOSDIS	EOS Data and Information System
EROS	Earth Resources Observing System
ESDIS	Earth Science Data Information System
ETM+	Enhanced Thematic Mapper Plus

LPGS System Reqs/System Design Review

Acronyms

F&PRS	functional and performance requirements specification
FAST	an output format for L1 digital images
FDDI	fiber distributed data interface
FIFO	first in, first out
GB	gigabytes
GDS	ground data system
GeoTIFF	an output format for L1 digital images
GSFC	Goddard Space Flight Center
GUI	graphical user interface
HDF	Hierarchical Data Format
HWC	hardware component
HWCI	hardware configuration item
I/O	input/output
IAS	Image Assessment System
IC	internal calibrator
ICD	interface control document
IDD	interface data descriptions
IDL	Interactive Development Language
IGS	international ground station
ISO	International Standards Organization

LPGS System Reqs/System Design Review

Acronyms

L0R	Level 0R
L1	Level 1
L1G	Level 1G
L1R	Level 1R
LGN	Landsat ground network
LGS	Landsat 7 ground station
LPGS	Level 1 Product Generation System
LPS	Landsat 7 Processing System
M	meter
MB	megabytes
Mbps	megabytes per second
MDS	Manage Data Subsystem mm millimeter
MMO	Mission Management Office
MO&DSD	Mission Operations and Data Systems Directorate
MOC	Mission Operations Center
MSCD	mirror scan correction data
MTF	modulation transfer function
MTTR	mean time to restore
NASA	National Aeronautics and Space Administration
NCSA	National Center for Supercomputing Applications
NFS N	etwork File System

LPGS System Reqs/System Design Review

Acronyms

NOAA	National Oceanic and Atmospheric Administration
PC	personal computer
PCD	payload correction data
PCMB	Project Configuration Management Board
PCS	Process Control Subsystem
PGS	Process Geometry Subsystem
PRS	Process Radiometry Subsystem
QA	quality assessment
QAS	Quality Assessment Subsystem
RAID	redundant array of inexpensive devices
RMA	reliability, maintainability, and availability
RPC	remote procedure call RSI Research Systems, Inc.
RTM	Requirements and Traceability Management (tool)
SDR	system design review
SDS	system design specification
SGI	Silicon Graphics, Inc.
SNR	signal-to-noise ratio
SRR	ystem requirements review
SSR	solid-state recorder
SWCI	software configuration item
SQL	Structured Query Language

Acronyms

TBD	to be determined
TBR	to be resolved
TBS	to be supplied
TIFF	tagged image file format
URL	uniform resource locator
USGS	United States Geological Survey
WRS	Worldwide Reference System
WWW	world-wide web

REVIEW SUBJECT:	CONFIGURATION CONTROL BOARD	NUMBER (FOR CODE 514 CCB USE ONLY)
DATE OF REVIEW:	REVIEW ITEM DISPOSITION	
ORIGINATOR:	ORGANIZATION:	EXTENSION:

SUBJECT OF COMMENT:

DOCUMENT TITLE/NUMBER:

DESCRIPTION OF PROBLEM:

ORIGINATOR'S RECOMMENDATION:

IMPACT IF RECOMMENDATION NOT ACCEPTED:

ACTIONEE'S RESPONSE:

NAME OF ACTIONEE:	SIGNATURE:	DATE:

DISPOSITION

- ❑ APPROVED AS WRITTEN
- ❑ APPROVED WITH MODIFICATIONS
- ❑ DISAPPROVED

REVIEW BOARD CHAIRMAN:	DATE: